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A 30-Year Record of Surface Mass Balance (1966-95), and Motion and Surface Altitude (1975-95) at Wolverine Glacier, Alaska

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Cover. Wolverine Glacier and basin, August 20, 1986. Photograph taken by D.C. Trabant, U.S. Geological Survey.

A 30-Year Record of Surface Mass Balance (1966-95) and Motion and Surface Altitude (1975-95) at Wolverine Glacier, Alaska

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Fairbanks, Alaska 2004

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Contents

Figures

Tables

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square meter (m^2)	10.76	square foot
square kilometer (km^2)	0.3861	square mile
kilogram per liter (kg/L)	62.43	pounds per cubic foot
meter per year (m/yr)	3.281	foot per year
grad (angle)	0.9	degree (angle)
metric ton (t)	1.102	ton
degree Celsius (°C)	1.8, then add 32	degree Fahrenheit (°F)

VERTICAL DATUM:

In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929. Altitudes are the same in both the local coordinate system and the Universal Transverse Mercator system.

Symbols and abbreviations used in this report:

$b_0(i)$	initial ice balance at a site
$b_0(s)$	initial snow balance at a site
$b_1(i)$	final ice balance at a site
$b_1(ls)$	late snow balance at a site
$b(f)$	new firn balance
$b(k)$	internal accumulation at a site
$b(s)$	snow balance at a site
$b(i)$	old firn and ice balance at a site
b_a	annual snow, firn, and ice balance during a hydrologic year at a site
$b_a(f)$	annual new firn balance
$b_a(i)$	annual old firn and ice balance at a site
$b_m(s)$	measured snow balance at a site
b_n	yearly net firn and ice balance between times of minimum balance at a site

$b_n(f)$	net new firn balance (ice content only) at a site
$b_n(i)$	net balance of old firn and ice at a site
b'	average stake height of the glacier surface within a 3- to 5-meter radius
b'_0	stake height of the glacier surface at the beginning of a measurement period
b'_1	stake height of the glacier surface at the end of a measurement period
$b'(i)$	water equivalent of old firn and ice above a stake base
$b'ss$	height of a summer surface above the base of a stake
$b*$	surveyed stake height of the snow, firn, or ice surface
$b**$	stake height, vertical distance between base of a leaning stake and the glacier surface
d	snow depth or depth of snow that has become new firn
d or δ	as a prefix before any symbol means a change in that quantity
D_h	horizontal distance projected to a plane at sea level
$°d$	degree-days
e	emergence of the glacier surface during a measurement period
$\dot{e}$	emergence rate of the glacier surface
E	estimated snow density, when listed after density data in tables
f	Earth curvature and atmospheric refraction coefficient in optical surveying
LSnow	abbreviation for late snow, fresh snow on new firn
m	partially measured density, when listed after density data in tables
m(w)	meters depth of snow or ice in water equivalent
M	measured density, when listed after density data in tables
n	number of probes, pits, and cores taken at the time of each measurement
NFirn	abbreviation for new firn, snow that has survived the summer melt season
OFirn	abbreviation for old firn
P	precipitation
ρ	density of snow, firn, or ice
$\rho(s)$	density of snow
$\rho(w)$	density of water
$\rho(i)$	density of glacier ice
F	dip of glacier motion near surface
S	average glacier surface speed
S_e	average emergence speed
SFirn	abbreviation for superimposed ice in old firn
SIce	abbreviation for superimposed ice

ss_0	initial summer surface, the glacier reference surface for a measurement year
ss_1	final summer surface
S_{wi}	irreducible water-volume constant, water retained in snow by capillary retention
t_0	beginning of hydrologic year
t_1	end of hydrologic year
Q	horizontal glacier surface motion direction
UTM	Universal Transverse Mercator Projection
V	glacier motion vector
V_m	vertical angle to a geodetic monument
X	project grid coordinate, increasing easterly
Y	project grid coordinate, increasing northerly
Z	altitude above sea level; glacier surface altitude above sea level
Z_0	altitude of the glacier surface at the beginning of a measurement period
Z_1	altitude of the glacier surface at the end of a measurement period
Z_i	altitude of a surveying instrument
Z_m	altitude of a geodetic monument
Z_{ss}	summer surface altitude

A 30-Year Record of Surface Mass Balance (1966-95) and Motion and Surface Altitude (1975-95) at Wolverine Glacier, Alaska

By Lawrence R. Mayo, Dennis C. Trabant, and Rod S. March

ABSTRACT

Scientific measurements at Wolverine Glacier, on the Kenai Peninsula in south-central Alaska, began in April 1966. At three long-term sites in the research basin, the measurements included snow depth, snow density, heights of the glacier surface and stratigraphic summer surfaces on stakes, and identification of the surface materials. Calculations of the mass balance of the surface strata - snow, new firn, superimposed ice, and old firn and ice mass at each site were based on these measurements. Calculations of fixed-date annual mass balances for each hydrologic year (October 1 to September 30), as well as net balances and the dates of minimum net balance measured between time-transgressive summer surfaces on the glacier, were made on the basis of the strata balances augmented by air temperature and precipitation recorded in the basin. From 1966 through 1995, the average annual balance at site A (590 meters altitude) was -4.06 meters water equivalent; at site B (1,070 meters altitude), was -0.90 meters water equivalent; and at site C (1,290 meters altitude), was +1.45 meters water equivalent.

Geodetic determination of displacements of the mass balance stake, and glacier surface altitudes was added to the data set in 1975 to detect the glacier motion responses to variable climate and mass balance conditions. The average surface speed from 1975 to 1996 was 50.0 meters per year at site A, 83.7 meters per year at site B, and 37.2 meters per year at site C. The average surface altitudes were 594 meters at site A, 1,069 meters at site B, and 1,293 meters at site C; the glacier surface altitudes rose and fell over a range of 19.4 meters at site A, 14.1 meters at site B, and 13.2 meters at site C.

INTRODUCTION

Research into mountain climate, glacier responses to climate, and glacier runoff at Wolverine Glacier in the coastal, maritime Kenai Peninsula of southcentral Alaska (fig. 1) began with measurements in April 1966. This study at Wolverine Glacier is the only long-term, continuous monitoring effort investigating climate, glacier processes, and glacier hydrology in the highly glacierized coastal mountains of southcentral Alaska.

Wolverine Glacier, approximately 18 km^2 in area and 7 km long, is one "link" in the International Hydrological Decade's (1964–75) North-South American "chain of glaciers" from the Antarctic Peninsula to Arctic Alaska (UNESCO, 1970). Two other glaciers in this chain are under routine observation by the U.S. Geological Survey (USGS): South Cascade Glacier in the maritime North Cascade Range of Washington (Krimmel, 1999); and Gulkana Glacier in the continental Alaska Range of interior Alaska (March and Trabant, 1998). Kahiltna and Traleika Glaciers near Mt. McKinley in the Alaska range have been observed since 1990 by the U.S. National Park Service using the same methods used at Wolverine and Gulkana Glaciers.

Three sites (fig. 1) were established on Wolverine Glacier for mass balance measurements. In this report, only surface mass balances are reported for these sites; internal freezing and melting processes are known, but not discussed here. In 1975, additional measurements of glacier surface altitude at fixed locations and ice motion began at the three sites. The purpose of establishing these three sites was to make year-round measurements of mass balance, flow, and surface altitude changes continuously over the long periods of time required for climate change research. The complete time-series of measurements of glacier mass balance, motion, and surface-altitude at each of these sites are presented in tables and graphs in this report.

ACKNOWLEDGMENTS

Research began at Wolverine Glacier as a result of the recognition that glaciers can be significant in both local and global water balance equations. Yet, few reliable data exist for glaciers. Many of the research concepts applied at Wolverine Glacier originated with Carl Benson, Herfreid Hoinkes, Mark Meier, Gunnar Østrem, Hans Rothlisberger, and Wendell Tangborn. Their pioneering work was essential.

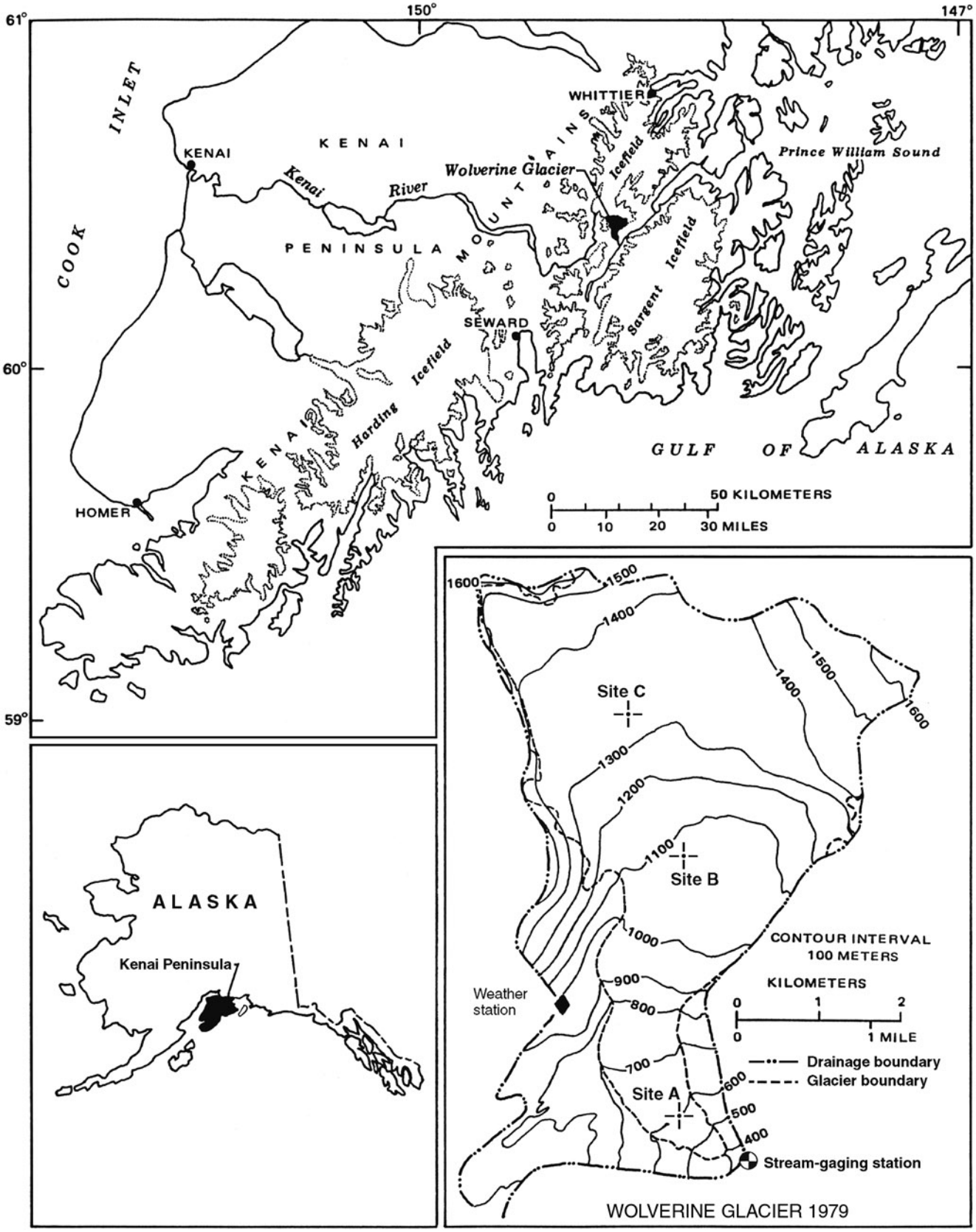

Figure 1. Location of Wolverine Glacier, Kenai Peninsula, south-central Alaska, showing the principal measurement sites in the basin.

Wolverine Glacier is in a remote area of Alaska where weather and terrain conditions are severe. Even under ideal conditions, the work is not easy and patience is required to accomplish it. The work was interrupted frequently for 2 to 10 days by high winds, blowing snow, and fog that make glacier and helicopter travel impossible.

Stanley Jones devoted two years coping with these conditions—sometimes with no shelter available—to assist in establishing the necessary scientific equipment and other facilities. Later, several other people assisted in the investigation at Wolverine Glacier, both in winter and summer. These individuals include principally Chester Zenone, David Scully, and Gail Mayo, all of whom contributed to the research program. They were resourceful in accomplishing equipment repairs, contributing useful ideas, and made some of the initial calculations in the data sets. About 30 other individuals also assisted at Wolverine Glacier.

During the 30-year period, small teams of glaciologists travelled safely to Wolverine glacier a total of 115 times to maintain the continuous, year-round measurement campaign. The cooperation of all these people helped to ensure the safety and success of the measurements at Wolverine Glacier for three decades. The authors, as well as the science of glaciology, are indebted to the cumulative efforts of these scientists.

Robert Krimmel, William Harrison, Timothy Brabets, Elizabeth Snyder, Sonja Benson, Ben Kennedy, and Dave Meyer reviewed this report and offered useful suggestions that improved its clarity.

DESCRIPTION OF THE MEASUREMENT SITES

The three long-term measurement sites at Wolverine Glacier (fig. 2) are located in relatively flat parts of the glacier to minimize the damaging effects of snow creep on stakes. Site A, at 590 m altitude, is low in the glacier's ablation area. Site B, at 1,070 m, is normally high in the ablation area, but during years with large positive mass balances, it is low in the glacier's accumulation area. The glacier surface at site B in late summer is a complex mixture of old firn, superimposed ice, and iced firn (firn permeated with water because it is near the glacier's equilibrium line). When this slushy mixture refreezes during the subsequent winter, it usually has a density of 0.90 kg/L. Site C, at 1,290 m, is normally in the accumulation area of the glacier except during years with large negative mass balances, when it is very high in the ablation area.

During the first 2 years of observation, 1966 and 1967, the measurement sites were not at fixed locations; instead, the glacier's mass balance was mapped (Meier and others, 1971; Tangborn and others, 1977). The data presented in this report for those years are from the mass balance maps and the nearest measurement stake. The fixed measurement sites featured in this report were established in 1968. In 1975, sites A and B were moved about 100 m to the glacier's centerline, which was defined for glacier-volume-change surveys. In 1978, site C was moved 208.4 m northeastward to the glacier's centerline.

A weather recording station was established at 990 m elevation near the western boundary of the glacier basin (Mayo and others, 1992; see fig. 2). The station is slightly lower than the glacier's average equilibrium line altitude and approximately 500 m from the west edge of the glacier. Air temperature and precipitation are recorded at the site since 1967.

SURFACE MASS BALANCE

The methods of glacier mass balance measurement at Wolverine Glacier evolved from those described in Meier (1960), Meier and Tangborn (1965), Østrem and Stanley (1969), Mayo and others (1979), and Mayo and Trabant (1982); and are similar to the methods used at several Alaska glaciers: Black Rapids Glacier (Heinrichs and others, 1995), and Gulkana Glacier (March and Trabant, 1998), Columbia Glacier (Mayo and others, 1979), and more recently at Kahiltna and Traleika Glaciers. The specific methods used at Wolverine Glacier are described in this report. The internal mass balance, consisting of internal accumulation (Trabant and Mayo, 1985) and internal ablation (Mayo, 1992), is not analyzed here.

Mass balance measurements at the surface of a glacier consist of measuring the changes in snow and ice that result from the cumulative effects of snow precipitation, snow compaction, melting of snow and ice, wind erosion of snow, freezing of water, and sublimation from ice. The measurements are simple in concept, that is, repeated measurements of the height of the glacier surface on stakes installed in the glacier, snow depths, and snow densities, and identification of the mass balance stratum at the surface of the glacier, such as snow, new firn, old firn, superimposed ice, and glacier ice. Making these simple field measurements is often physically demanding and potentially dangerous because of the frequently inclement weather and the remoteness of the site. Maintaining a continuous measurement program also is made difficult because stakes are distorted by glacier movement and snow and wind loading, snow pits require laborious excavation, travel can be dangerous, and snow probing and coring-auger samples do not always produce reliable measurements of the base of the annual snow layer.

Each year's mass balance measurements at a stake are referenced to the previous year's summer surface. The data resulting from these measurements are listed in the data files using a combined system, both as the net balance, b_n, in the stratigraphic system, and also as the annual balance, b_a, in the fixed-date system following the concepts developed by Mayo and others (1972).

The reference plane for each year's measurement, the summer surface, separates different glacier mass balance stratigraphic units, or strata. The summer surface is a time-transgressive feature on a glacier (fig. 3). It forms during

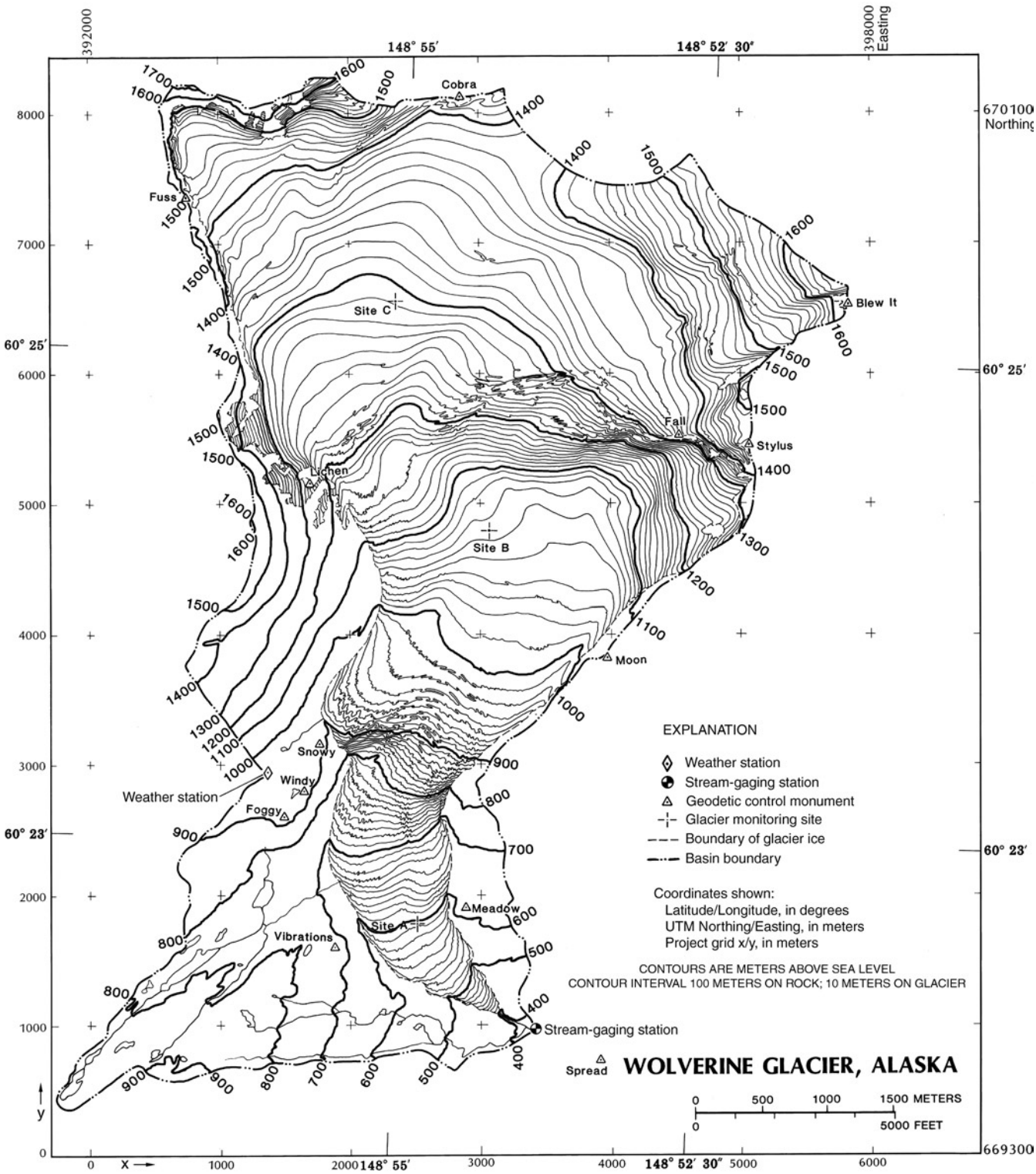

Figure 2. Locations of long-term measurement sites and geodetic control monuments in Wolverine Glacier Basin, Alaska. (Map compiled from August 3, 1979, aerial photography and surveyed control panels)

the early fall at the top of the glacier, and then progressively later at lower altitudes as winter sets in. The amount of time required for the formation of this summer surface over the entire glacier varies from year to year depending on the local weather, typically taking 2-4 weeks at Wolverine Glacier.

Thus, the net new firn and ice balances, $b_n(f)$ and $b_n(i)$, at the three sites on Wolverine Glacier do not represent the same time period. Annual mass balances, b_a, on the other hand, are reported for each fixed-date hydrologic year beginning October 1 and ending the following September 30. The balance data

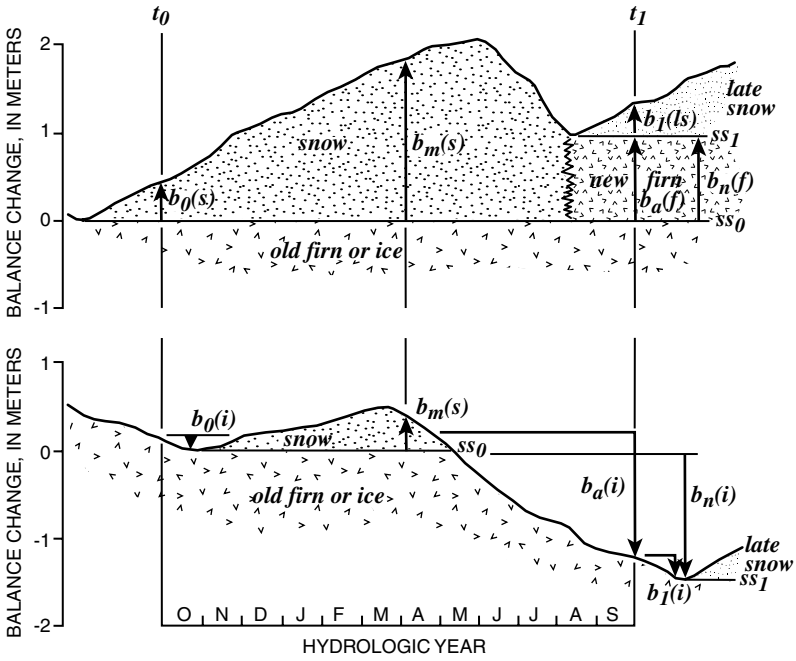

Figure 3. Mass balance quantities measured at two different locations on a glacier. [Measurements made using the stratigraphic system referenced to the summer surface that moves with the glacier (Lagrangian coordinates). Annual balance quantities are obtained from these data by reference to the balance conditions at the beginning and end of the hydrologic year (Mayo and others, 1972). Symbols are: t_0, beginning of hydrologic year; t_1, end of hydrologic year; $b_0(s)$, initial snow balance; $b_1(ls)$, late snow balance; $b_m(s)$, measured snow balance; $b_n(f)$, net new firn balance; ss_0, initial (reference) summer surface; ss_1, final summer surface; $b_0(i)$, initial ice balance; $b_1(i)$, final ice balance; $b_n(i)$, net ice balance; $b_a(f)$, annual new firn balance; and $b_a(i)$, annual old firn and ice balance]

together with air temperature and precipitation data from the basin are used to estimate the small changes in mass balance between the measured balances, the minimum balance, and the balance for the fixed-date year beginning on October 1.

Stakes

Each stake set in the glacier is labeled with a unique identification name and installed in a hole drilled with a manual auger or a steam drill. The stakes are 1-inch-(25-mm)-diameter metal electrical conduit cut to lengths of 3 m, and connected with short flanged pipes that fit inside the ends of each stake section. Small holes are drilled in the conduit precisely at 0.5-m intervals to serve as height markers and to let water out. A wood plug is driven into the base of each stake to prevent it from sinking into the ice. In the early years, the need for the wood plugs was not appreciated, so occasionally they were not used and some of these stakes sank into the ice.

At site A, a new stake is usually installed in September of each year to a depth of 10 to 11 m with about 3 m exposed above the ice surface for measurements in winter. No connector is put at the 6-m joint so the stake will come apart at that point during the following summer melt period. The stake is adjusted to be 3 m above the ice surface in the fall. At site B, a new stake is installed about every 2 years to a depth of 9 m. Each fall, stakes at site B that are in good repair are extended 4 to 5 m above the surface for winter measurements. At site C, stakes are installed about 3 m deep into old firn almost every year and extended to 4 to 5 m above the summer surface in the fall. In mid-winter, the stake again is extended to 3 m above the snow surface.

If a stake becomes buried during winter and cannot be found, another stake is installed nearby. If both the old and new stakes are found at a later date, they can be measured and surveyed simultaneously. Assuming that the stakes' relative positions are constant, the balance and position of the temporarily lost stake can be accurately estimated, thus providing an unbroken measurement series.

Stake Measurements

At the time a stake is installed, and during each successive visit, the stake name and height of the snow, firn, or ice surface, (*b'*), on the stake are measured and recorded (fig. 4). Generally, snow and firn surfaces at Wolverine Glacier are smooth, without large wind features such as sastrugi and snow dunes. However, local relief on glacier ice surfaces commonly is 0.2 to 0.5 m.

Snow Pits and Cores

Both snow density and direct measurements to buried summer surfaces are possible when pits are dug in snow and firn. In very deep snow, a pit is dug through part of the snow, and auger core samples are taken from the floor of the pit to the base of the snow. If the snow is less than 3 m deep, coring of the snowpack is possible by simply thrusting a long tube into the snow. Because snow density is difficult to measure, relatively few measurements have been made at Wolverine Glacier, and most of those were made before 1980. Continuous vertical coring of the snow in pit walls using relatively large diameter coring tube (72.3 mm) that is 0.6-m long, produces highly accurate snow density data. However, auger coring is often discontinuous, with gaps in the core where the snow was very soft; in these cases, the density of missing layers was estimated. Pit and auger-coring sites are far enough

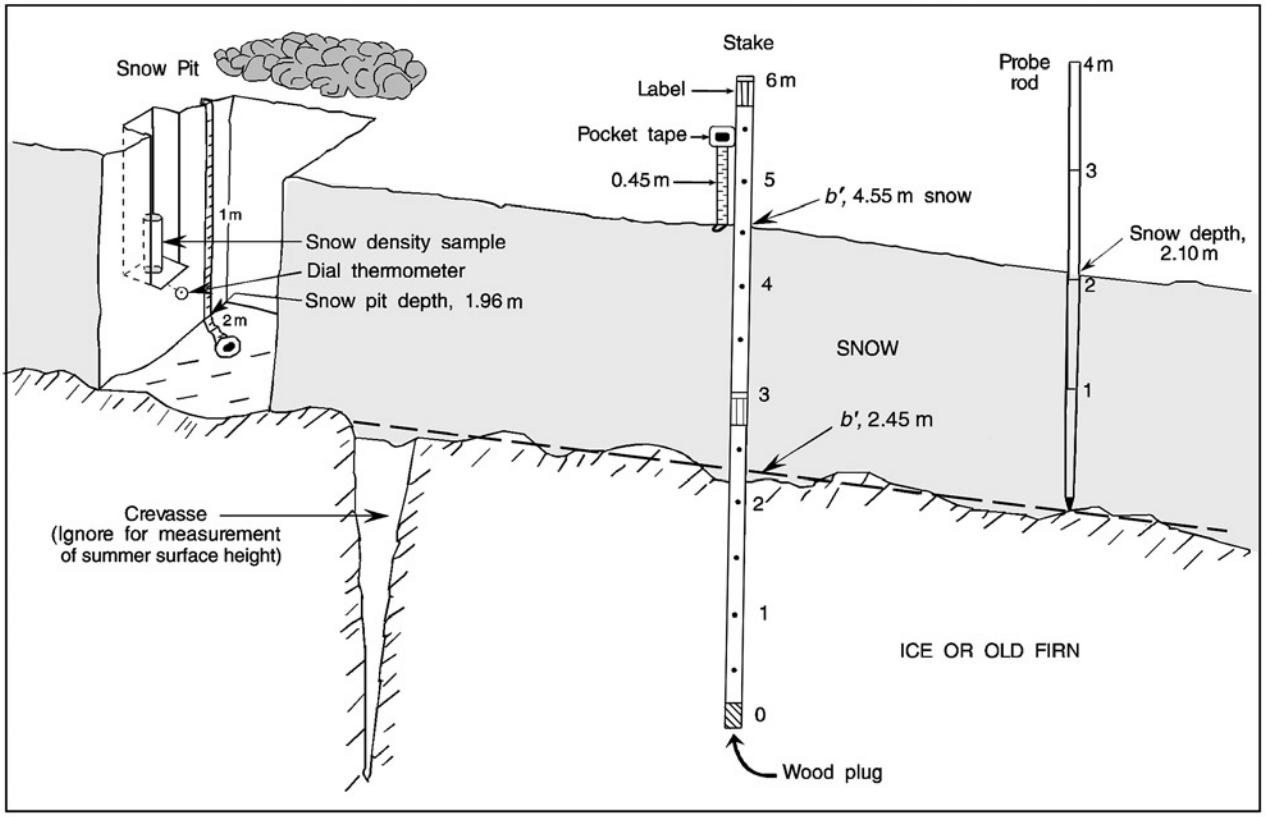

Figure 4. Surface mass balance measurement site showing snow pit, stake, and snow probe measurements. (*b'*, average stake height of the glacier surface within a 3- to 5-meter radius; *b'ss*, height of summer surface above the base of the stake; *m*, meters)

from stakes so that stake and snow near the stake are not disturbed. As a result snow depths at pits may be slightly different from snow depths at stakes. A total of 107 snow pits and cores at Wolverine Glacier successfully produced snow density and depth measurements for the full depth of the snowpack (table 1). [Note: all tables are in a section at the back of this report]. Additional snow density measurements in the upper part of deep snowpacks are listed in the mass balance tables (tables 2, 3, and 4).

Snow Probing

Snow depths in the ablation area of Wolverine Glacier are measured with a probe rod if the snow is less than about 6 m deep, the ice at the summer surface is very hard, and a false summer surface (a very hard layer in the snow) is usually absent. When possible, 5 to 10 probe measurements are made within a 3- to 5-m radius of the stake to obtain the average snow depth. In this way, errors caused by local variations of snow depth and surface roughness near the stake are reduced. Sometimes the summer surface, especially in the accumulation area, is difficult or impossible to identify when probing. All probing data are listed in the mass balance tables in this report; however, some data were disregarded because subsequent measurements indicated that the probing did not produce the correct snow depth. Probing, while relatively easy, is the least reliable measure of snow depth at Wolverine Glacier.

Summer Surfaces

Summer surfaces (ss_0 and ss_1, fig. 3) at Wolverine Glacier are usually easily identifiable, but in some instances, can be difficult to identify if they are very clean. Care is taken with all measurements to ensure that the reference summer surface is identified correctly. Several problems can arise with identification of a summer surface. (1) A false summer surface can be created by a fall storm with mixed rain and snow, which forms a slush layer. When the slush freezes, a solid false summer surface is formed. Even though it feels like glacier ice with a probe, careful observation in a pit can reveal that the hard layer does not have a concentration of dirt at its surface, and that it overlies an identifiable dirty summer surface. (2) Occasionally, no dirt accumulates on the snow surface during the summer. (3) Thick ice layers may form in the snow during severe winter ice storms or during spring when meltwater percolates into cold snow. These can stop a probe rod and give the appearance of a solid ice surface at the floor of a snow pit. (4) Even in the ablation area, summer surfaces may be misidentified because a layer of ice usually forms at the base of the snow overlying cold glacier ice in spring when meltwater

refreezes. At Wolverine Glacier, layers of transient, superimposed ice are commonly 0.01 to 0.05 m thick.

In the glacier's accumulation area at site C, a 1-m^2 piece of plywood with a hole in the center is placed over the stake and lowered to the surface each fall. During subsequent measurements, the plywood is used to positively identify the previous summer surface. However, even this technique is not foolproof because investigators have believed several times that they were probing to the plywood, whereas other measurements indicated that they had been probing to an ice layer in the snow above the plywood. The best method to ensure accuracy of snow depth data with a plywood marker is to use a steam drill to penetrate to the plywood. Additionally, sawdust and wire meshes can be placed on the surface during late summer to identify it, but plywood is the easiest and most effective. Plywood markers can also be used for glacier motion analysis when a stake is buried by snow.

Mass Balance Data

The glacier surface mass balance tables for Wolverine Glacier (tables 2, 3, and 4) present the measurements, necessary interim calculations, and mass balance results for each site in meters of water equivalent, m(w), for each surface stratum of the glacier: snow, new firn, old firn, superimposed ice, and old firn and ice. For clarity, all measurements that were needed to calculate the mass balance at a site are included with each measurement year, even though some duplication results from year to year. Each stake is identified by its name, and information is given about the date of installation and any unusual features of the stake. Explanations of each column in the tables are given in the following paragraphs.

Measurements

Field Notes: This column references the original field notes on file at the Fairbanks office of the USGS. This reference is included to expedite further research that might require access to related observations.

Date: Measurement dates are in month/day/year format. Specific dates relating to the beginning and end of each measurement year are also listed. These include the date of minimum balance at the beginning of the net-balance year, the date of the beginning of each fixed-date hydrologic year (October 1), the date of the minimum balance at the end of the net-balance year, and the date of the end of the fixed-date hydrologic year (September 30).

Stake Heights: Tape: Each stake measurement, *b'*, is the height in meters on the stake from the base of the stake to the glacier surface. The measurement incorporates a visually estimated average surface height within a 3- to 5-m radius of the stake. Standard practice is to mark this height on the stake and then measure to the point with a pocket tape from the nearest height mark (hole) in the stake. If measurements of more than one stratum are made, the entries are recorded; for example, both the snow surface and superimposed ice surface are recorded for stake 66-3 on 4/23/66 (table 2).

Survey: Beginning in 1978, each stake was surveyed at two points—one well above the glacier surface, and the other at the glacier surface. The glacier surface point as viewed with a theodolite, *b**, may not be precisely the same point as the *b'* measurement, so both are listed. Another stake height, *b***, is a calculated value that has been corrected for stake lean or other distortions. Stake heights are corrected for lean by first calculating the lean of the stake top using the surveyed position data, then calculating the stake bow if in snow, and finally calculating the coordinates of the stake base using any lean previously measured for the lower sections of the stake. This method was developed by Hodge (1972) for use at Nisqually Glacier, Washington. The calculated vertical distance from the stake base to the sloping glacier surface directly above it is listed as *b***. This value would have been the stake height had the stake been vertical. In calculations of mass balance involving stake heights, *b*** values are used instead of *b'* values when available, because mass balance quantities are always considered to be vertical measurements.

Stratum: Identification of the stratum at a glacier surface is essential to interpretation of mass balance. Surface strata include snow, superimposed ice, new firn, old firn, glacier ice, and "superfirn," a mixture of old firn and superimposed ice. To save space in the data tables, these are listed, respectively, as Snow, SIce, NFirn, OFirn, Ice, and SFirn. New snow from a recent storm and old snow are distinguished in some places.

- *Snow* includes all ice layers and liquid water contained in the snow. On a glacier, the summer surface identifies the base of the snowpack. Late snow resting on new firn is part of the snow accumulation during a hydrologic year and is also part of the snow strata observed during the subsequent measurement year.

- *Superimposed ice* (SIce) is a layer of ice on top of glacier ice that forms by freezing of water in the base of the snowpack. Superimposed ice that forms during the spring, then remelts during the summer, is termed "transient superimposed ice." The density of superimposed ice at Wolverine Glacier is estimated to be 0.9 kg/L because of the relative absence of air bubbles.

- *Firn* is snow that has survived at least one summer's melting and becomes part of the net accumulation added to the glacier. New firn (NFirn) refers to the increment of firn that forms on a glacier during a specific measurement year. The new firn of one year becomes old firn (OFirn) thereafter. The density of old firn ranges from about 0.6 to 0.9 kg/L.

- *Glacier ice* is metamorphosed old firn that can also include additional ice that froze within the glacier. Glacier ice is identified by its large grain size (0.02 to 0.15 mm in diameter), highly compressed air bubbles, and foliation structure. The density of glacier ice at Wolverine Glacier has not been measured, but is assumed to

be 0.90 kg/L because it contains relatively few gas bubbles. The density of pure ice is 0.917 kg/L.

- *Superfirn* (SFirn), a new term introduced in this report, is firn that has become saturated with water and refrozen. This combination of superimposed ice and firn has been observed by the authors on numerous glaciers near the equilibrium line following one or more years of positive mass balance in locations where firn overlies glacier ice. Superfirn is fine grained, has numerous small air bubbles, is horizontally stratified, and has a dirty summer surface at the top, similar to firn. The density of superfirn is near 0.9 kg/L.

Snow Depth: Snow depth is calculated from the field measurements. First, the stake height of each summer surface ("Obsvd. *b′ss*", tables 2, 3, and 4) is calculated as either *b***, *b**, or *b'* minus the average snow depth. Next, the average summer surface height, Average *b'ss*, for the entire winter is calculated by weighting the measurements by the number (*n*) of probes, pits, and cores made at the time of each measurement. This is the most reliable measure of the height of the reference summer surface at a stake. Finally, the snow depth, *d*, is the difference between the stake heights, *b***, *b**, or *b′* and the average summer surface height, average *b'ss*. This system utilizes all relevant information at each stake to produce the most representative snow depth at a stake.

The very deep spring snowpack at site C in 1981 was difficult to measure and required detailed notation than normal in the mass balance data set (table 4). The 1980 reference summer surface at site C was difficult to document because all of the stakes were buried and digging a snow pit deeper than 10 m was not feasible. Probing through cold winter snow on January 26, 1981, defined a hard layer at a depth of 6.7 m, and hard surfaces that felt like firn at depths of 10.25 and 10.42 m. Four corings on January 27, 1981, exposed a grain size increase from 0.5-mm diameter to 1.5-mm diameter at a depth of 12.00 m. On June 7, 1981 core samples were taken from the site (surveyed and assuming average glacier motion) where sawdust was spread on the snow surface in August 1980. These samples were melted to search for debris that might indicate a summer surface. One sawdust particle and numerous small vegetation fragments were found in the sample that came from the depth interval from 13.4 to 13.7 m; the coring auger flights held two more sawdust particles. Checks of field notes from earlier years show that sawdust had not been put at this site previously. Stake 81-C2 was placed on a small wooden base in this core hole. On September 2, 1981, a core sample from the sawdust site contained an abrupt change in snow grain size at a depth of 9.65 m, which was about the same level relative to the stake as the sawdust found earlier. Coring on September 25, 1981, did not identify a summer surface nor did it go deep enough to encounter the previously identified grain size changes or sawdust layer. Analysis of the reference summer surface (table 4) determined that the grain size change found at 12.00-m depth found on January 27, 1981; the sawdust at an average depth of 13.55 m on June 7, 1981, and the abrupt grain size increase found at 9.65-m depth on September 2, 1981, are the 1980 summer surface. Therefore, the snowpack was concluded to have reached a depth of 13.6 m by June 5 or 6, 1981, and to have been 9.4-m deep on September 11, 1981, the end of the summer. Although this is not the record snow depth for Wolverine Glacier (15.2 m was measured on June 7, 1977, at 1,530-m altitude), the snow depth at site C in 1981 was greater than expected, judging from the snow depths at sites A and B.

Pit: Snow depth measured at a pit in which the summer surface can be identified visually is the most reliable method. However, it is a measurement at only one point and the observation is laborious, so pit studies are made much less frequently than other types of snow depth measurements.

Probe: Snow depths measured by probing become more reliable when done in conjunction with pit measurements, because false summer surfaces that are exposed in the pit can be identified when probing. Probing can be done quickly at a number of points, so probing is useful in establishing the average snow depth, especially in the ablation area, which has a rough ice surface. If a snow pit was not made to confirm the probing horizon, depth measured by snow probing was verified by previous evaluations of the stake height of the summer surface whenever possible.

Average, standard error, and number of snow depth measurements: Snow depth measurements use all of the pit and probe data on a given date. However, because the snow depth, *d*, at a stake is the difference between the stake height of the glacier surface (*b***, *b**, or *b′*) and the average summer surface height (*b′ss),* it is not an independent evaluation of snow depth and is, therefore, not included in the calculation of standard error (*s.e.*) or counted in the number (*n*) of measurements. The average of the direct snow depth measurements is used when no measurements at a stake are available.

Summer Surface: Observed: Stake heights of reference summer surfaces, *b′ss* (fig. 4), are listed as "Obsvd." in the mass balance data tables (2, 3, and 4) for each combination of stake and snow-depth measurement.

Average: When the summer surface heights cluster about a central value, the *b′ss* on the stake is assigned the average value. A series of summer surface heights that continuously rise relative to the stake indicate that the stake is sinking into the glacier and the average stake height is not used for mass balance calculations.

Surface Mass Balances

Old Firn and Ice: Density is mass per unit volume. Snow and ice densities are used to convert linear measurements of depth and stake height to water equivalent values. The "stake-reference" old firn and ice balance, *b'(i)*, in meters water equivalent, m(w), is the product of summer surface average height, *b'ss*, on the stake and the density of the stratum. This interim value, *b'*(*i*), is the basis for calculating the amount of old firn and glacier ice that melts during the summer and is posted in tables 2, 3, and 4. The annual ice balance,

$b_a(i)$, is the difference between the amount of old firn and ice, $b'(i)$, at the beginning of the measurement year and the amount remaining at the end of the year.

Accurate snow and firn density data are essential for mass balance measurements. A total of 107 full-depth snow and firn density measurements were made at Wolverine Glacier (table 1) for this study. Numerous other partial-depth measurements were made also and are reported with the stake data (tables 2, 3, and 4).

Samples of snow and firn for density measurements are continuous vertical cores rather than horizontal cores. Vertical core sampling produces accurate average density data for each depth interval cored (Østrem and Stanley, 1969). Horizontal cores produce accurate information about internal layering for identifying snow and firn strata (Benson, 1959), but the data can be difficult to interpret to obtain the average density of a stratum. At Wolverine Glacier, vertical coring was chosen for its accuracy and speed, and summer surfaces were identified as by searching for dirty layers. Although this method works in most years, the dirt marking summer surfaces at Wolverine Glacier is not distributed uniformly, so it can be missed by a coring auger. Occasionally, there is no dirt on the summer surface at Wolverine Glacier.

The accuracy of measuring snow density has not been studied at Wolverine Glacier. Some investigators, for example, George Claggett, U.S. Department of Agriculture Snow Surveyor,oral communication, 1984, have estimated that small samplers, such as the McCall (11.61 cm^2 cross-section area) push-type sampler, may under-sample loose snow by about 6 percent. Larger samplers, such as the Norwegian tube (41.05 cm^2) are estimated to be accurate to within 2 percent in firm snow.

Density measurements of deep snow tend to be more accurate than measurements of shallow snow because more samples of deep snow are collected, and random errors tend to cancel when the average density is calculated. Snow density measurements in this report are posted to three digits and the sampling method is identified (table 1). Reporting values is probably more precise than can realistically be obtained but was done so that precise corrections can be applied in the future for each method, thus avoiding additional errors associated with rounding. This is consistent with the standard practices followed for performing all calculations with more significant digits than can be measured absolutely and rounding the final result.

Snow and New Firn: The snow balance, $b(s)$, for any date is the snow depth, d, at the stake multiplied by the density of snow, $\rho(s)$. The product has the dimension of depth in meters of water equivalent, m(w), after the density has been converted to a relative density with respect to water, $\rho(s)/\rho(w)$.

Snow Density: Snow density, $\rho(s)$, can be measured (M), partially measured (m), or estimated (E) from generalized knowledge of snow density as a function of snow depth and date. Density can be measured by one or a combination of methods -- various core sampling devices, vertical coring in a pit wall, and occasionally extended in depth by vertical coring from a pit floor to the base of the snow.

Two methods have been used for estimating snow density when snow depth is the only measurement. In one method, the snow density is measured in the upper part of the snowpack and an estimate of the unmeasured lower part of the snowpack is made. To do this, reliable snow density measurements are plotted so that the average density above any specified depth in a snowpack is shown (fig. 5). When the density measured

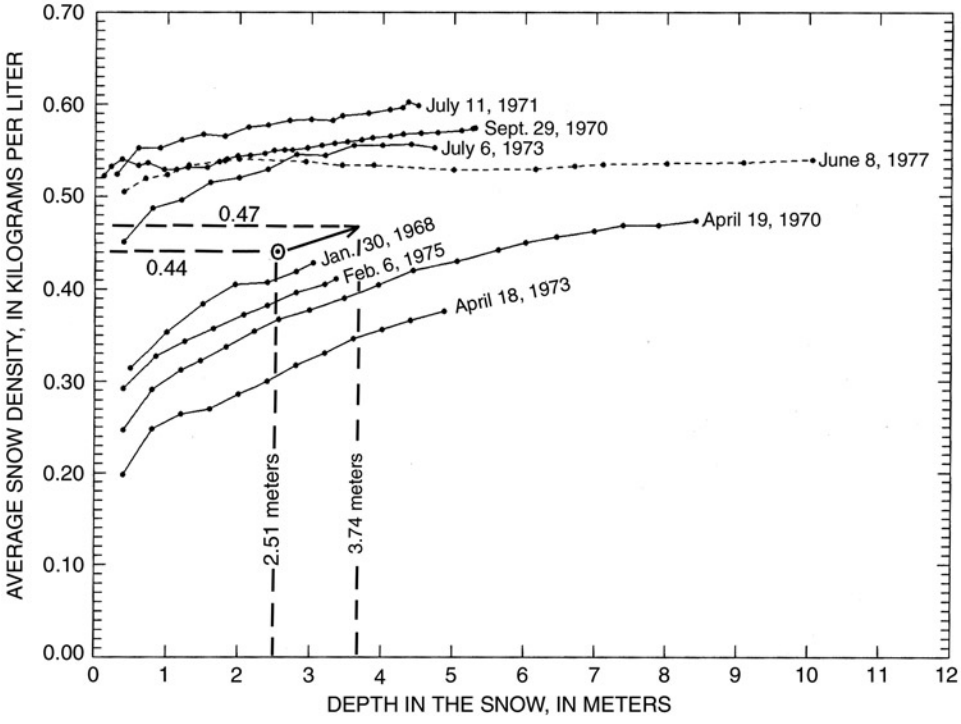

Figure 5. Average snow density above specified depths in the snow for different dates, Wolverine Glacier, Alaska. (The circled dot shows a measurement of snow density at site B on May 13, 1992 of 0.44 kilograms per liter average density to a partial depth of 2.51 meters. The average density for the entire snowpack of 3.74 meters depth is estimated from this graph to be 0.47 kilograms per liter)

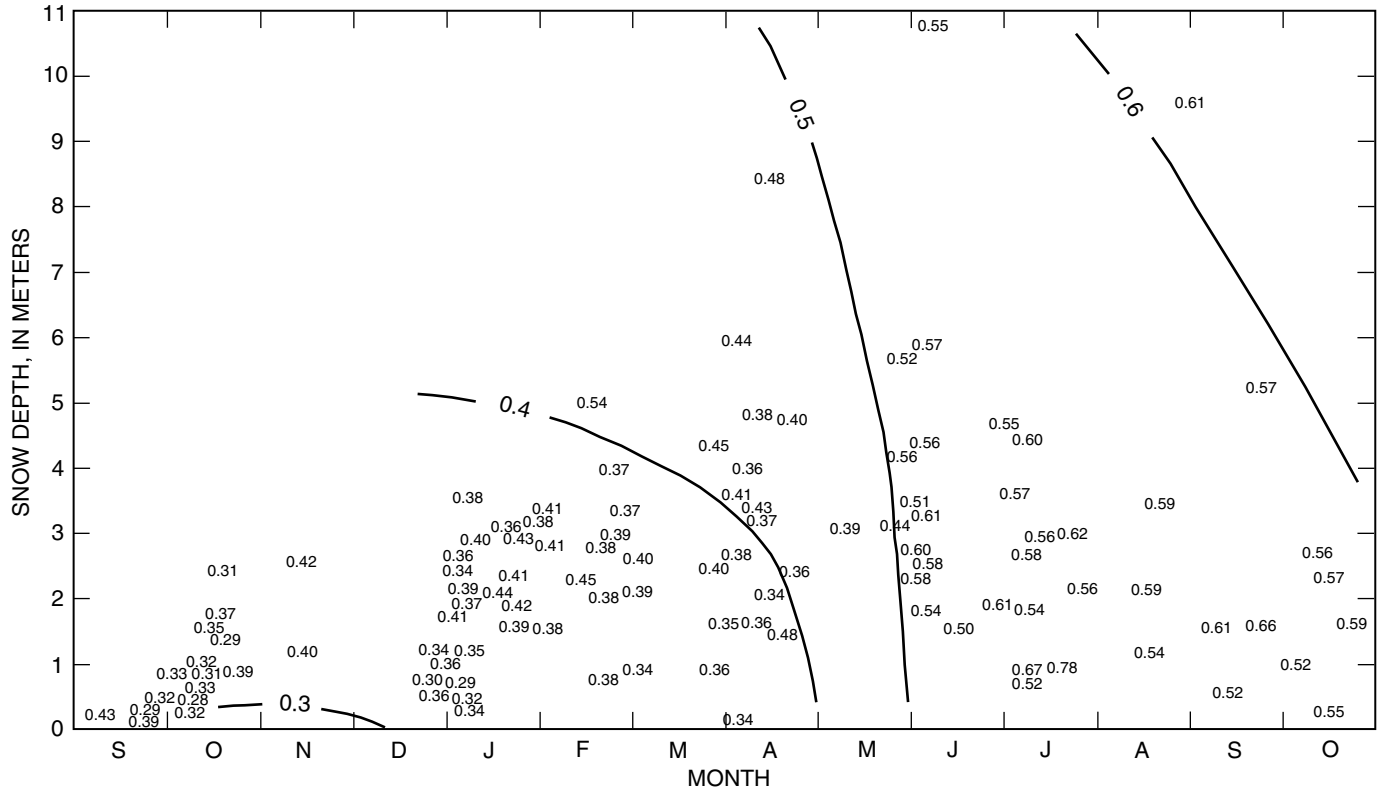

Figure 6. Average snow and new firn densities (numerals) at Wolverine Glacier, Alaska, as a function of snow depth and age, on the date of measurement. (Contours are a generalization from the data and are used for estimating snow density when only snow depth and date are known. Density values are kilograms per liter)

in the upper part of the snowpack is plotted, the density for the entire snowpack can be estimated by assuming that the increase in snow density with depth is a reasonable estimate of the density of the unmeasured part of the snowpack. Snow density entries based on partial measurements are given the notation *"m*" in the mass balance data tables (tables 2, 3, and 4).

If no snow density is measured, the average density of the entire snowpack must be estimated. Snow depth and density data for Wolverine Glacier (table 1) show that snow and new firn densities increase both with depth and with age, where age is defined in terms of the date of measurement (fig. 6). The generalized contours of density on figure 6 are used to obtain the density estimates listed in the mass balance data tables (tables 2, 3, and 4); these estimates are indicated by the notation "E."

NFirn: New firn, $b_n(f)$, is the seasonal snow remaining at the time of minimum balance at the end of the summer in the accumulation area of a glacier. Snow that becomes new firn is a mixture of ice crystals, liquid water, and air. However, only the ice component of the snow becomes a relatively permanent addition to the glacier. The liquid component is in temporary storage. Some of it is converted into internal accumulation, *b(k)*, by freezing during the next winter (Trabant and Mayo, 1985); the rest drains from the glacier as the firn compresses gradually into glacier ice. The liquid component of new firn creates a potential problem in glacier mass balance accounting, because the same material could be counted twice, once in the new firn, and a second time when it freezes. At Wolverine Glacier, the liquid component is subtracted from the snow balance when snow becomes new firn.

The liquid component is analyzed separately for determining the amount of internal accumulation that will be included in the new firn. The rest of the liquid is assumed to become part of the glacier's runoff. The amount of ice (without water) contained in new firn, $b_n(f)$, at Wolverine Glacier, is calculated by subtracting the water volume retained by capillary retention, 0.07 of the void space of the old snow, from the snow balance, *b(s)*:

$$b_n(f) = b(s) - S_{wi}[d(1-\rho(s)/\rho(i))], \quad (1)$$

where

S_{wi} is the irreducible water volume constant, the water retained in snow by capillary retention (Colbeck, 1974);

d is the depth of snow that becomes new firn;

$\rho(s)$ is the snow density that is measured (bulk density including water); and

$\rho(i)$ is the density of ice, assumed to be 0.9 kg/L.

Yearly Results: The last two columns of the mass balance tables are the total surface mass balances summed for the two periods defined in the combined glacier mass balance system (Mayo and others, 1972). The net balance, b_n, is the snow, firn, and ice balance accumulated since the previous minimum balance at the beginning of the net-balance year when the initial summer surface formed. The annual balance, b_a, is the sum of the snow, firn, and ice balance accumulated since October 1, the beginning of the fixed-date hydrologic year.

Both the stratigraphic system (net) and the fixed-date system (annual) mass balances are derived from the same field measurements. The initial snow and ice balance at each site are listed for the dates of minimum balance and the beginning of the hydrologic year. During a year, several stakes may be measured at a single site. Frequently only one stake is judged to be reliable, so that stake is used to compute the mass balance for the site. For other years, measurements from several stakes are averaged for determining the mass balance of the site. Balance measurements made during the year result in "year-to-date" values listed under the "Yearly Results" heading (tables 2, 3, and 4). The net balance of old firn and ice, $b_n(i)$, is zero during the winter. For this reason, only the annual old firn and ice balances, $b_a(i)$, are tabulated separately (tables 2, 3, and 4).

Other mass balance quantities can be identified or calculated from the measurements. For example, the initial snow balance, $b_0(s)$, is the new snowpack on the glacier at the beginning of a hydrologic year. This value is listed in tables 2, 3, and 4 as the snow balance, *b(s),* on October 1. Similarly, the initial ice balance, $b_0(i)$, is the loss of ice after October 1 and before winter accumulation begins. The quantity is the difference between the ice balance at the stake, *b'(i),* on October 1 and the *b'(i)* listed for the date of the minimum balance, when the minimum balance occurs after October 1. In other words, this is the part of a year's net balance that occurs after the beginning of the next fixed-date year.

End-of-Year Estimates

For field safety reasons, the last visit of the summer usually is made before the time of the minimum balance and seldom precisely at the beginning of the fixed-date mass balance year, on October 1. The field safety concerns are that shortly after the time of minimum mass balance, thin new snow bridges form over crevasses and intense winter storms prevail at Wolverine Glacier; both increase the dangers of surface access to and movement in the vicinity of the measurement sites.

The net balance minima and balance values for the end of the fixed-date (hydrologic) year are measured or estimated using late summer measurements of air temperature and precipitation and the mass balances measured before and after the end of summer. Minimum values for the net mass balance are actually measured during subsequent winter field visits, before the next spring melting begins. However, the time of occurrence of the net mass balance minima and the mass balance at the end of the hydrologic year must be estimated.

A simple mass balance model is used to estimate the date of the net balance minimum and the adjustment values needed to evaluate the mass balance at the end of the hydrologic year. The model is applied to the period between the measured mass balances that bound the end of summer and uses the average lapse rate of air temperature between the nearby coastal city of Seward, 17 m altitude (fig. 1), and Wolverine Glacier, 990 m altitude, of -5.8°C/1,000 m (calculated from data in Mayo and others (1992), Kennedy (1995), and tables 5 and 6 in this report). Daily precipitation at each site is estimated by using the ratio of snow accumulation at each site and the precipitation-gage catch (tables 7 and 8) for periods when there is no snowmelt. Snow and rain are differentiated by assuming that wet snow falls when the daily average air temperature is between 0°C and +1.7°C, as documented elsewhere (U.S. Army, 1956, p. 55). During periods when temperatures are within that range, snow accumulation and snowmelt occur simultaneously. Dry snow is assumed to accumulate when the daily average temperature is below 0°C, and rain is assumed to be falling when the daily average temperature is above +1.7°C at each site. The model estimates ablation on the basis of the daily average air temperature and the rate of icemelt expressed in meters of water equivalent per degree-day, m(w)/°d (table 9). A melting rate of -0.0045 m/°C-day is used to estimate the melting of wet snow and glacier ice.

The date of the net mass balance minimum at each site is estimated by using the model to evaluate daily snow and ice balances for the period after the late-summer field trip. After the date of the net mass balance minimum is determined, the mass balance at the end of the hydrologic year is evaluated.

If the net mass balance minimum occurs before the end of the hydrologic year, the amount of accumulation between the two dates must be estimated. This estimated quantity is termed the late snow balance, $b_l(ls)$. The late snow balance is evaluated for the period between the net balance minimum and the end of the hydrologic year as the cumulative value of the modeled daily precipitation as snow.

If the net mass balance minimum occurs after the end of the hydrologic year, the amount of melting of snow and ice between the two dates is estimated. This estimated quantity is termed the final ice balance, $b_l(i)$. The final ice balance is evaluated for the period between the end of the hydrologic year and the time of the net balance minimum by accumulating the number of degree-days warmer than 0°C at each measurement site and multiplying by the average melt rate.

The estimated quantities are small increments of mass balance that are added to or subtracted from the field measurements to determine the annual mass balance for the hydrologic year. The estimated quantities are different for each site and each year. However, the estimated quantities introduce no cumulative errors in mass balance because the final ice balance increments, $b_l(i)$, and late snow balance, $b_l(ls)$, of one year become the initial balances, $b_o(i)$ and $b_o(s)$, of the next year.

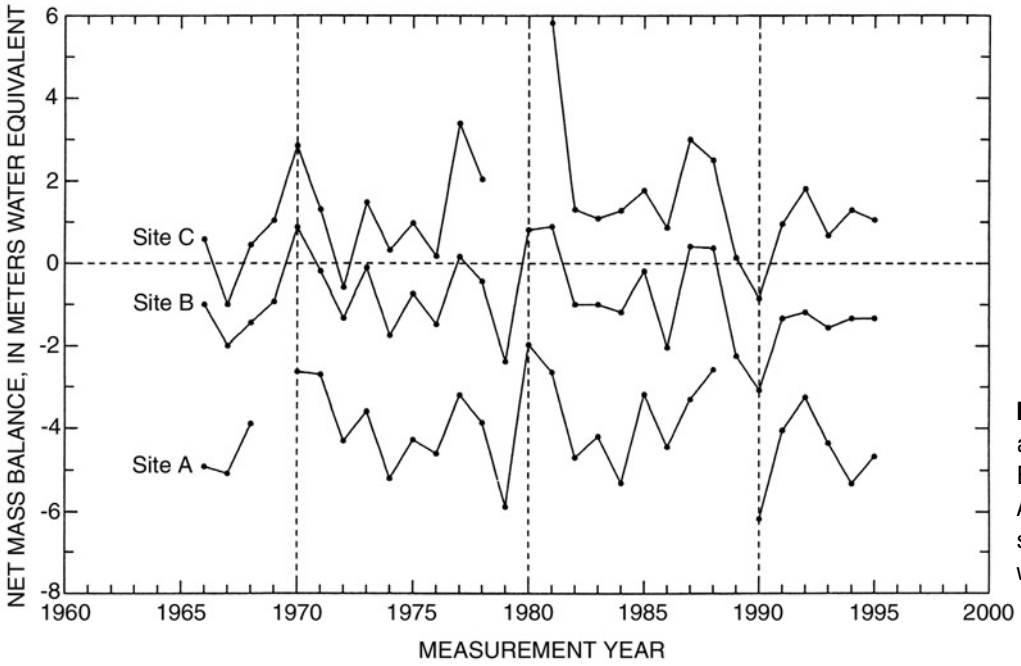

Figure 7. Yearly net mass balance measurements at sites A, B, and C on Wolverine Glacier, Alaska. (Lines connecting measurements are discontinuous where data are missing)

All the mass balance measurements from April 1966 through January 1996, the estimated balance-minimum dates, and end-of-year balances are listed in tables 2, 3, and 4 for each measurement stake. The net and annual mass balances from 1966 through 1995 at three sites on Wolverine Glacier are summarized in table 10 and in figure 7.

GLACIER MOTION AND SURFACE ALTITUDES

Geodetic Monuments

Permanent geodetic monuments are installed at Wolverine Glacier at strategic locations (fig. 2) where the snow usually is blown away. The monuments are visible from the glacier because the reference points are the tops of cement-filled pipes that extend above the rock, except the monument Stylus, which is a sharp, rocky peak, and Precip, which is the precipitation gage orifice at the weather station. These monuments provide year-round reference marks for all motion and glacier surface altitude measurements. The coordinates assigned to the monuments are based on the Universal Transverse Mercator Projection (UTM Zone 6). A local, rectilinear coordinate system at Wolverine Glacier has its origin at UTM Easting = 392,000 m and Northing = 6,693,000 m; NAD 27; its linear scale is located at sea level.

The coordinates of the monuments (table 11) evolved from 1976 to 1979 for several reasons. First, the altitude of the surface where the horizontal scale is calculated in the local system changed, initially at 1,000 m altitude, and finally at sea level. Second, eventually all angles and all sides of adjacent triangles were measured, which improved the accuracy. Third, the coordinates were based, at first, to geodetic monuments having coordinates that pre-dated the 1964 Good Friday earthquake (9.2 Richter magnitude) in south-central Alaska. Before 1979, the horizontal coordinates represented pre-earthquake positions. The altitude control at Wolverine Glacier, however, was based on the pre-earthquake positions of control monuments but corrected for the lowering of 0.9 m measured in nearby coastal areas (Plafker, 1969).

In 1979, the USGS established post-earthquake coordinates in the southern region of Alaska to correct for the considerable crustal movement that accompanied the 1964 earthquake. The 1979 coordinates at Wolverine Glacier (Net79, table 11) are based on surveys to the glacier from control monuments having post-1964 earthquake positions. The horizontal coordinates of Net79 are at sea level.

Project grid coordinates (Net79) at Wolverine Glacier can be converted to UTM (Zone 6) coordinates with the following equations:

$$\text{UTM Easting} = 392{,}000 + 0.999735X \quad (2)$$

$$\text{UTM Northing} = 6{,}693{,}000 + 0.999735Y \quad (3)$$

Great care was taken at Wolverine Glacier to establish accurate monument coordinates. All sides and angles of each adjacent triangle were measured. Then the angles and side lengths were adjusted within the measurement uncertainty to form mathematically correct figures. Accurate vertical angles were measured simultaneously between two survey theodolites located over each of two monuments so that the effects of Earth curvature and atmospheric refraction could be determined and eliminated in the process of defining the precise altitude differences between monuments. As a result, adjacent

monuments have relative position accuracies on the order of 0.01 to 0.02 m in *X*, *Y*, and *Z* coordinates, and the cumulative uncertainty over the entire geodetic network is on the order of 0.10 m. High relative precision of monument coordinates enables the analysis of variable atmospheric refraction conditions that result from variable weather conditions during each glacier survey. Thus, variable atmospheric conditions do not introduce vertical errors in stake positions and glacier surface altitudes at Wolverine Glacier.

Geodetic surveys before 1979 either were shifted by the amounts indicated in table 11 or recalculated using Net79 coordinates. In either case, accuracy is maintained within about ±0.05 m. Final values are rounded to 0.1 m because glacier surface roughness and stake deformation produce larger uncertainties in the glacier motion results than do the surveys.

Site Surveys

Accurate measurements of stake positions and glacier surface altitudes are made routinely at sites A, B, and C at Wolverine Glacier at the same time that mass balance measurements are made. A description of the survey methods used at Wolverine Glacier is given here because some of the methods are very useful for glacier research but are not described in standard surveying texts.

To reduce the time required for the measurements, any of four survey methods can be used: resection, foresight, and intersection (see Mayo and Trabant, 1982, for details). The method selected is the one that requires the least travel. Surveys are made most frequently with a theodolite set up on the glacier surface. Its precise location is determined by the resection method. The local targets then are surveyed by short foresights. At site A, intersection from two easily accessible monuments sometimes is used if the stake does not need attention, thus avoiding a hike to the site. Occasionally, when crevasses block access to the stakes or when many stakes are visible, intersection surveys are made to the stakes from two accessible resection sites.

To set up a theodolite on the glacier, three small plywood boards are placed in holes chopped in the ice or stamped firmly into the snow to serve as supports for the tripod legs. A period of 5 to 10 minutes is sometimes required between the initial setup and the beginning of the survey to allow the supports and the instrument to stabilize. If the temperature is above 0°C, snow or ice is placed on the tripod feet to shield them from the effects of sunlight and warm air.

After the theodolite is stable, measurements are made to three monuments to determine the coordinates of the instrument by resection. The closest monument typically is used as the principal reference, and then a second monument is observed. The principal monument is surveyed a second time to detect any instrument motion. Immediately, the third monument is measured, and a final closing measurement of the principal monument is made. This produces eight independently measured horizontal angles between the monuments, six vertical angles to the principal reference monument, and two vertical angles to the other two monuments.

The horizontal angle data are used to calculate the instrument's horizontal location by the resection method that is explained in standard surveying texts (for example, Moffitt and Bouchard, 1987).

To reduce the effect of variable meteorological conditions, the measured vertical angles are used to solve for two unknowns: the Earth curvature/atmospheric refraction coefficient, *f*, and the altitude of the surveying instrument, Z_i, using a technique developed by the authors for surveying at large mountain glaciers (Mayo and others, 1979). The method requires using two equations to solve for the two unknowns. The equation used to calculate the instrument altitude is:

$$Z_i = Z_m - D_h \tan V_m - f D_h^2, \quad (4)$$

where

Z_m is the monument altitude,

D_h is the horizontal distance between the instrument and the monument, and

V_m is the vertical angle to the monument.

The second equation is the same as the first (equation 4) but uses a second monument, its altitude, and the measured vertical angle to it. In the general case, the subscript, *m*, is replaced by A, B, or C to identify the monuments. Because Z_i must have a single value, the right sides of the two equations can be equated. Then, assuming that the combined Earth curvature and refraction coefficient, *f,* has a unique value:

$$f = \frac{Z_B - D_{hB} \tan V_B - Z_A + D_{hA} \tan V_A}{(D_{hB})^2 - (D_{hA})^2}. \quad (5)$$

Once the curvature and refraction coefficient, *f*, is known, the instrument altitude, Z_i, can be calculated using equation 4.

In practice, the measurements to the three monuments are paired in three combinations, AB, BC, and CA. This results in three independent determinations of Z_i and *f. S*ome care must be exercised in interpreting these results. For example, as the horizontal distances to the two monuments approach the same value, the denominator of equation 5 approaches zero and the ability of this technique to determine Earth curvature/atmospheric refraction diminishes. The strongest solution for *f* is where the difference in the distances to two monuments is relatively large. Knowing this, the surveyor can select an optimal group of monuments for a resection. The coefficient *f* normally ranges from about 0 to 70 $\times 10^{-9}$. If *f* is 0, light travels along a curve that is the same as Earth curvature; the Earth appears to be flat and there is no correction. This can be caused by temperature inversion conditions. If *f* is 70 $\times 10^{-9}$, then the vertical correction is 0.28 m at a horizontal distance, D_h, of 2,000 m. Values outside these limits are rejected if there is a reason to suspect they are weak. For example, sometimes the exact top of a monument is not clear in the telescope view.

If that is noted, calculations of *f* using that monument are also suspect.

The final instrument altitude, Z_i, is determined using only the reliable vertical measurements and strong solutions for *f*. The result of this altitude determination process is that variable atmospheric refraction conditions do not contaminate the data. Thus, resection location data are relatively accurate despite the fact that instruments are set up on snow and ice and that they are calculated on the basis of monuments located at some distance away at the margin of the glacier.

After the theodolite location is established by resection, care is taken not to disturb the instrument when foresight surveys to the stake and glacier surface are made. Local survey targets include two points on each stake: one above the glacier surface and a second at the glacier surface. These two surveys enable calculation of stake lean and the position of the base of the stake.

The glacier surface altitude at a fixed location is measured during each visit by surveying three points on the glacier surface. The points form a triangle surrounding a horizontally fixed measurement site, enabling calculation of the surface altitude at the fixed location (the horizontally fixed sites are listed later in the "Surface Altitudes" section). In some cases, the glacier surface beneath the surveying instrument serves as one of these points and the glacier surface at the stake often serves as a second point, so only one additional surface point is needed. To help select the three surface points, the field crew carries a map showing the expected location of the stake relative to the horizontally fixed surface altitude measurement site.

Glacier Motion

The base of a stake is the most reliable point to follow for glacier ice motion determination because the stake base is affected least by stake lean. Stake positions listed in tables 12, 13, and 14 are the coordinates of the bases of the stakes. The average ice speed between surveys is calculated from the stake displacement in three dimensions and the number of days between surveys divided by 365.25 days per year. This results in speed expressed as meters per year. Stake locations are calculated initially to 0.01-m accuracy, then rounded to 0.1 m because of uncertainties about the stake lean and the location of the stake base. The uncertainties of stake position surveys are on the order of 0.1 to 0.2 m in the horizontal and 0.05 to 0.10 m in the vertical.

Glacier motion directions, both horizontal and vertical, are reported using the grad angular unit, in which 100 grads is a right angle. Horizontal motion direction is reported using standard rectangular to polar coordinate conversions where zero is east and the positive direction is counter clockwise from east. Vertical motion direction also is reported in grad units where horizontal is zero and positive is upward.

Sometimes stakes are temporarily lost because they are buried by deep snow. Nevertheless, the glacier motion record can be maintained without interruption. A buried stake sometimes can be found by predicting where glacier motion has moved it, then finding that location by surveying and digging a wide pit at the site. In one case, the stake was not found in the initial pit, but a compass indicated its presence in the snow behind the pit wall, where it was, indeed, found.

The method used for recovering glacier motion data from a temporarily lost stake is to install another stake near the buried stake and survey it. Later, when both stakes become visible, both are surveyed to determine their relative positions. Assuming that the two stakes have maintained their relative positions, the coordinates of the buried stake can be calculated for the dates when only the replacement stake was surveyed. This procedure sustains a continuous glacier motion record, even when deep snow interrupts sequential measurements. When this Procedure is used, the mass balance data tables (tables 2, 3, and 4) list a stake as buried, but the ice motion tables (tables 12, 13, and 14) indicate estimated coordinates for the buried stake and a calculated stake height, b'.

Surface Altitudes

Glacier surface altitudes at horizontally fixed locations are calculated for the following three sites on Wolverine Glacier (Mayo and Trabant, 1982):

Site	*X* (meters)	*Y* (meters)
A	2502.6	1773.0
B	3075.8	4796.9
C (before 2/28/78)	2160.5	6473.6
C (after 2/28/78)	2353.1	6553.2

Snow depths reported in the mass balance tables (tables 2, 3, and 4) are transferred to the ice motion tables (tables 12, 13, and 14) to calculate the altitudes of buried summer surfaces. Surface altitude and snow depth values are rounded to 0.1 m for calculations of summer surface altitudes and the emergence component of motion because that is the general precision of determining glacier surface altitudes.

Emergence (fig. 8) is the vertical component of glacier motion measured near the surface of a glacier (Meier and Tangborn, 1965). In other words, emergence is a measure of how much glacier motion would change the thickness of the glacier at a location that is fixed in space if the mass balance were zero. The motion is emergent if the vector is directed upward; that is, the glacier would become thicker at this location if the mass balance were zero. The motion is submergent (negative emergence) if the vector is directed downward; the glacier would become thinner at this location if the mass balance were zero. The emergence for a period can be determined as the difference between the change in altitude of the glacier

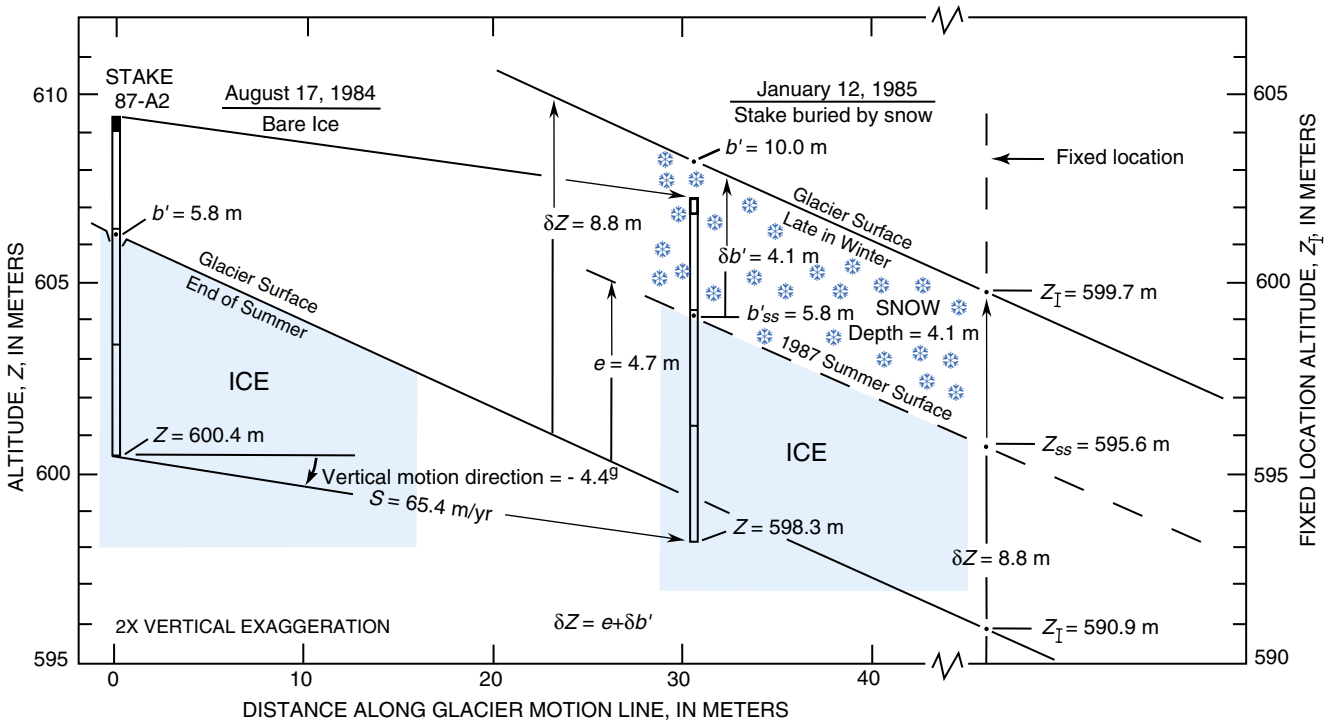

Figure 8. Vertical section along the glacier flow line at Site A on Wolverine Glacier, Alaska, showing the relations among mass balance measurements, stake positions, components of glacier motion, and surface heights from August 17, 1984, to January 12, 1985. (The diagram shows a single stake at two different times and the fixed location. Stake heights of the glacier surface (*b'*) are listed in tables 2 and 12. The method used to evaluate the position of a temporarily buried stake using a second, nearby stake, is defined in text section "Glacier Motion." Consecutive positions of stake 87-A2 (*X*, *Y*, and *Z*), glacier motion vector (*V*), stake readings (*b'*), altitudes of the glacier surface at the fixed-location measurement site (Z_I each date), and emergence (*e*) are listed in table 12. The upward emergence (*e*) caused by the vertical angle of motion being less steep downward than the glacier's surface slope indicates that the glacier would have become 4.7 meters (m) thicker at this site during the measurement period if the mass balance had been zero. However, 4.1 m of snow accumulated between the two dates and, as a result, the glacier altitude increase, δ*Z*, was the total of 4.7 m (emergence) + 4.1 m (mass balance) = 8.8 m. Other abbreviations: *b'ss*, height of summer surface above base of stake; *Zss*, summer surface altitude; g, grad angular units; m/yr, meters per year)

surface at a fixed location and the altitude effect of the mass balance change during the period (eq. 6 and fig. 8).

The emergence, *e*, for the period between surveys is:

$$e = (Z_1 - Z_0) - (b'_1 - b'_0), \qquad (6)$$

where

Z_1 is the altitude of the glacier surface at the fixed site at the end of the period,

Z_0 is the altitude of the glacier surface at the fixed site at the beginning of the period,

b'_1 is the stake height of the glacier surface at the end of the period, and

b'_0 is the stake height of the glacier surface at the beginning of the period.

The emergence rate, $\dot{e}$, in meters per year, is the emergence, *e*, divided by the time period, in years. Emergence and emergence rate are tabulated on tables 12, 13, and 14.

RESULTS OF SURFACE MASS BALANCE, MOTION, AND ALTITUDE MEASUREMENTS

Thirty years of net and annual mass balances from April 1966 through the 1995 measurement year at three sites on Wolverine Glacier are summarized in table 10 and in figure 7. The estimated balance-minimum dates, end-of-year balances, and all the field measurements are listed in tables 2, 3, and 4 for each measurement stake. The average annual balance at site A (590 meters altitude) was -4.06 meters water equivalent; at site B (1,070 meters altitude), -0.90 meters water equiva-

lent; and at site C (1,290 meters altitude), +1.45 meters water equivalent.

Glacier ice motion measurements began in February 1975; the data are listed through January 1996. The measurements provide a 21-year record of seasonal glacier surface speeds (figs. 9, 10, and 11) and glacier surface altitude fluctuations (figs. 12, 13, and 14). A small number of breaks in the record are caused by extreme conditions, such as the burial of stakes by snow, snow depths too great for reliable probing, or summers with large amounts of melt that caused stakes to fall before they could be reset. The average surface speed at the three sites from 1975 to 1996 was 50.0 m/yr at site A, 83.7 m/yr at site B, and 37.2 m/yr at site C. Surface speeds ranged from a minimum of 34.1 m/yr to a maximum of 74.0 m/yr at site A; from 67.4 to 100.3 m/yr at site B; and from 27.3 to 50.3 m/yr at site C. In response to mass balance and glacier motion variations, glacier surface altitudes rose and fell over a range of 19.4 m at site A, 14.1 m at site B, and 13.2 m at site C. The average surface altitudes were 594 m at site A, 1,069 m at site B, and 1,293 m at site C.

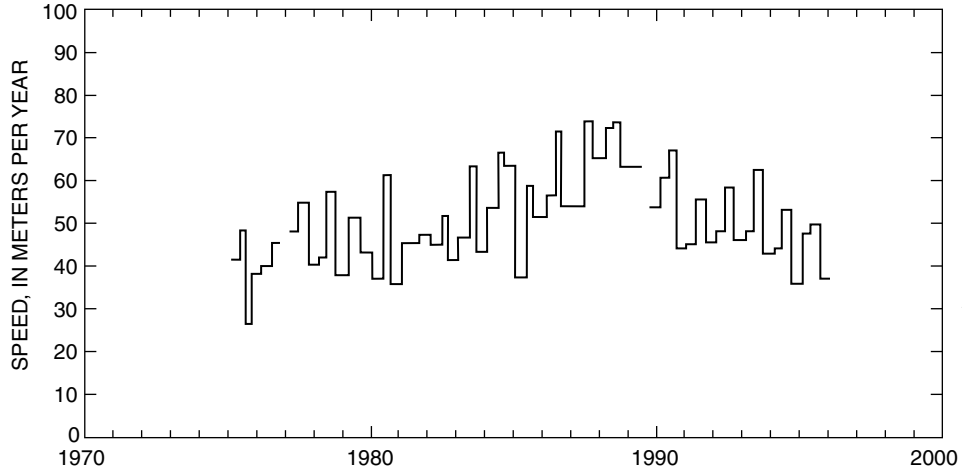

Figure 9. Glacier surface speed at site A on Wolverine Glacier, Alaska. (When more than one stake was measured during a period, the average speed is plotted. Lines are discontinuous where data are missing)

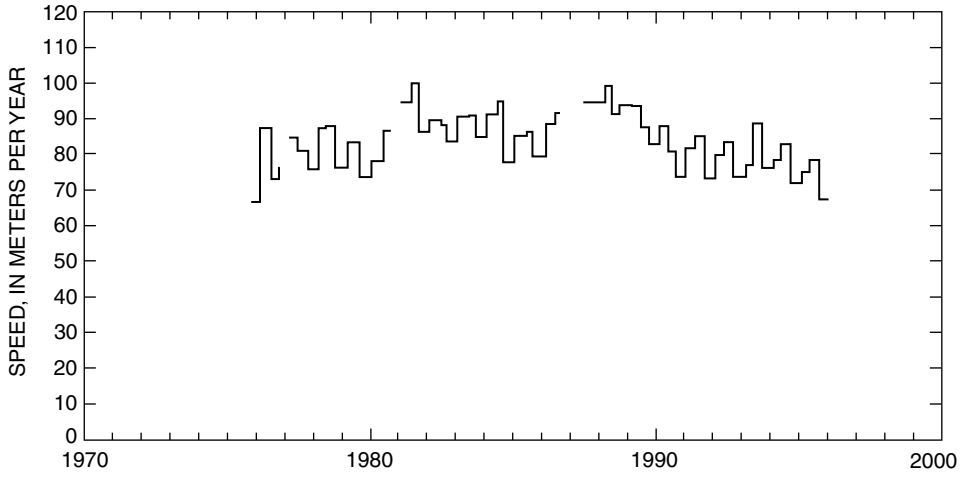

Figure 10. Glacier surface speed at site B on Wolverine Glacier, Alaska. (When more than one stake was measured during a period, the average speed is plotted. Data for stakes located more than 100 meters from the flow line though the measurement site are not shown. Lines are discontinuous where data are missing)

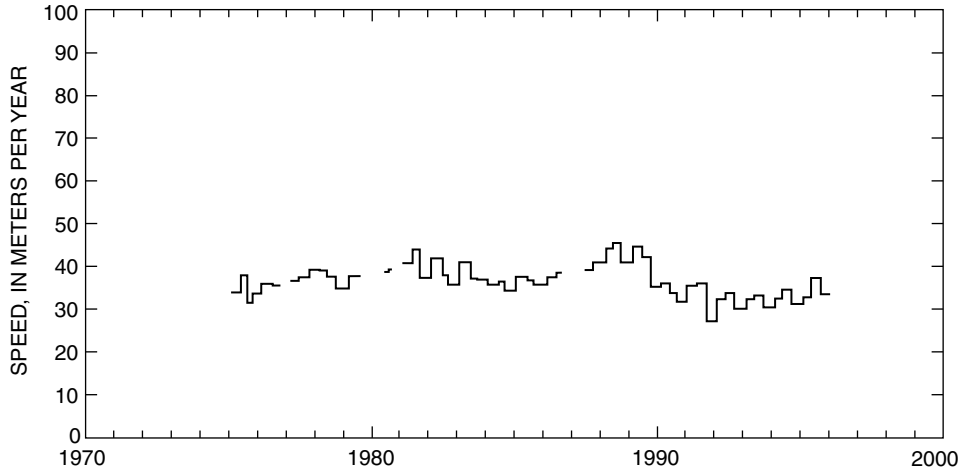

Figure 11. Glacier surface speed at site C on Wolverine Glacier, Alaska. (When more than one stake was measured during a period, the average speed is plotted. Lines are discontinuous where data are missing)

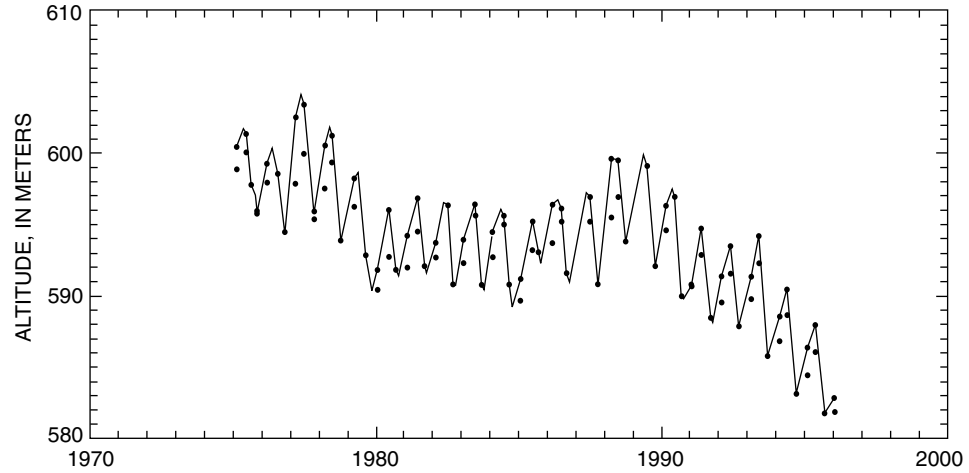

Figure 12. Glacier surface altitude at site A on Wolverine Glacier, Alaska. (The line connecting the surface altitude measurements also is drawn through estimates of the seasonal maxima and minima. Dots below the line representing the glacier surface indicate altitudes of summer surfaces buried under the snow)

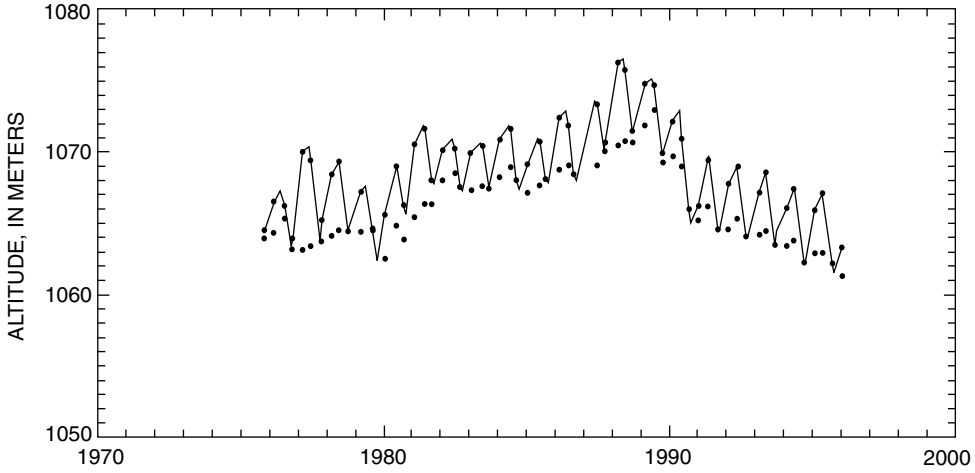

Figure 13. Glacier surface altitude at site B on Wolverine Glacier, Alaska. (The line connecting the surface altitude measurements also is drawn through estimates of the seasonal maxima and minima. Dots below the line representing the glacier surface indicate altitudes of summer surfaces buried under the snow)

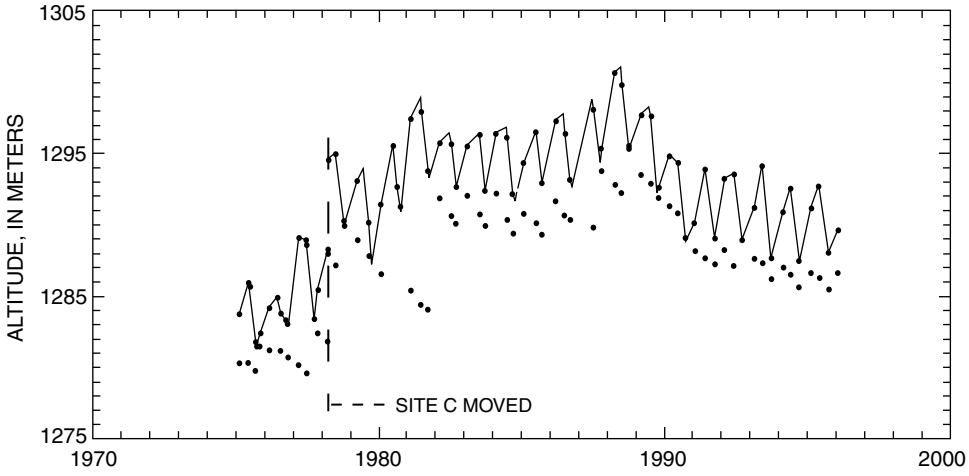

Figure 14. Glacier surface altitude at site C on Wolverine Glacier, Alaska. (The line connecting the surface altitude measurements also is drawn through estimates of the seasonal maxima and minima. Dots below the line representing the glacier surface indicate altitudes of summer surfaces buried under the snow)

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DATA TABLES 1–14

Table 1. Snow and new firn depth and density measurements at sites A, B, and C on Wolverine Glacier, Alaska. (Measurements made by snow pit or coring the layer and identifying the summer surface)

[Abbreviations: NFirn, new firn; PS, pit wall samples for density measurements taken with SIPRE tubes having a cross-sectional area of 26.24 cm^2; CS, core using a SIPRE 45.60-cm^2 sampling auger; PN, pit and Norwegian 41.05-cm^2 tube sampler; CN, core using a Norwegian 62.21 cm^2 sampling auger; PN/CN, combined pit and core below the pit floor to the summer surface using the Norwegian tube and auger; CM, core using a McCall 11.61-cm^2 tube sampler. All snow and firn samplers inserted vertically. Abbreviations of units: m/d/y, month/day/year; m, meters; kg/L, kilograms per liter. When NFirn and Snow are measured at the same pit, they are listed in the chronological order of the deposit's age]

Site A (altitude, 590 m)					**Site B** (altitude, 1,070 m)					**Site C** (altitude, 1,290 m)				
Date	Stratum	Depth	Density	Method	Date	Stratum	Depth	Density	Method	Date	Stratum	Depth	Density	Method
m/d/y		m	kg/L		m/d/y		m	kg/L		m/d/y		m	kg/L	
4/23/66	Snow	1.60	0.473	PS	4/01/67	Snow	0.97	0.362	PN	4/02/67	Snow	4.38	0.446	PN
4/04/68	Snow	2.52	0.397	PN	1/26/68	Snow	2.02	0.418	PN	1/30/68	Snow	3.04	0.428	PN
1/28/69	Snow	0.60	0.361	PN	4/08/68	Snow	3.64	0.413	PN	7/19/68	Snow	3.00	0.560	PN
4/13/69	Snow	1.69	0.364	PN	10/10/68	Snow	0.46	0.294	PN	8/22/68	Snow	1.21	0.536	PN
4/18/70	Snow	3.45	0.432	PN	1/27/69	Snow	1.64	0.392	PN	10/10/68	NFirn	1.04	0.519	PN
6/10/70	Snow	1.86	0.535	PN	4/12/69	Snow	4.05	0.356	PN	10/10/68	Snow	0.91	0.326	PN
1/09/71	Snow	0.79	0.291	PN	11/19/69	Snow	1.25	0.400	PN	1/26/69	Snow	2.40	0.410	PN
4/27/71	Snow	2.46	0.365	PN	4/11/70	Snow	6.00	0.442	PN/CN	6/03/69	Snow	5.78	0.518	PN
1/11/72	Snow	0.41	0.345	PN	6/09/70	Snow	4.40	0.569	PN/CN	7/31/69	Snow	2.20	0.560	PN
4/08/72	Snow	0.21	0.336	PN	7/24/70	Snow	3.02	0.615	PN	9/13/69	NFirn	1.60	0.614	PN
1/06/73	Snow	0.83	0.296	PN	1/11/71	Snow	2.02	0.369	PN	9/13/69	Snow	0.30	0.430	PN
4/19/73	Snow	2.13	0.341	PN	4/29/71	Snow	4.79	0.404	PN	11/19/69	Snow	2.62	0.422	PN
3/09/74	Snow	0.98	0.338	PN	7/10/71	Snow	3.65	0.570	PN	4/19/70	Snow	8.48	0.472	PN/CN
2/08/75	Snow	1.60	0.377	PN	10/16/71	Snow	0.83	0.305	PN	9/29/70	NFirn	5.11	0.584	CN
2/25/76	Snow	0.83	0.375	PN	1/13/72	Snow	1.25	0.350	PN	9/29/70	Snow	0.28	0.291	PN
2/22/77	Snow	5.06	0.539	PN	4/10/72	Snow	1.68	0.354	PN	1/08/71	Snow	2.70	0.361	PN
6/10/77	Snow	3.33	0.610	PN	6/21/72	Snow	1.60	0.502	PN	7/11/71	Snow	4.50	0.598	PN
3/02/78	Snow	3.00	0.389	PN	7/12/72	Snow	0.77	0.520	PN	10/19/71	NFirn	2.37	0.573	PN
6/09/88	Snow	2.64	0.587	CM	1/04/73	Snow	1.25	0.338	PN	10/19/71	Snow	1.59	0.351	PN
1/12/96	Snow	0.90	0.354	CM	4/16/73	Snow	3.30	0.371	PN	1/13/72	Snow	2.15	0.387	PN
					6/01/73	Snow	3.19	0.445	PN	4/10/72	Snow	2.73	0.384	PN
					10/12/73	Snow	0.38	0.324	PN	1/08/73	Snow	2.50	0.342	PN
					3/06/74	Snow	2.17	0.390	PN	4/18/73	Snow	4.87	0.376	PN
					6/08/74	Snow	2.39	0.579	PN	7/06/73	Snow	4.73	0.552	PN
					2/07/75	Snow	2.90	0.411	PN	10/16/73	NFirn	2.75	0.561	PN
					6/03/75	Snow	4.31	0.560	PN	10/16/73	Snow	1.06	0.325	PN
					10/27/75	Snow	0.48	0.320	PN	3/05/74	Snow	3.41	0.372	PN
					2/23/76	Snow	2.07	0.378	PN	6/08/74	Snow	3.50	0.508	PN
					7/12/76	Snow	0.97	0.671	PN	2/06/75	Snow	3.35	0.413	PN
					10/15/76	Snow	0.80	0.330	PN	8/19/75	Snow	2.18	0.587	PN
					6/11/77	Snow	5.90	0.570	CS	10/28/75	NFirn	1.66	0.594	PN
					10/24/77	Snow	1.52	0.294	PN	10/27/75	Snow	0.95	0.389	PN
					3/01/78	Snow	4.03	0.374	PN	2/23/76	Snow	2.90	0.381	PN
					3/07/79	Snow	2.67	0.404	PN	7/13/76	Snow	2.72	0.581	PN
					1/20/82	Snow	2.10	0.435	PN	10/20/76	NFirn	0.32	0.548	PN
					1/19/84	Snow	2.58	0.390	CM	10/20/76	Snow	1.84	0.365	PN
					10/01/87	Snow	0.47	0.316	PN	6/08/77	Snow	8.90	0.536	SC
					2/16/89	Snow	2.36	0.452	CM	10/25/77	Snow	2.50	0.308	NP
					1/06/91	Snow	1.12	0.364	CM	9/29/78	Snow	0.15	0.390	NP
					5/13/91	Snow	3.12	0.398	CM	9/02/81	Snow	9.65	0.600	CS
					1/22/92	Snow	3.15	0.355	CM	1/19/84	Snow	4.29	0.414	CM
					1/31/95	Snow	3.26	0.381	CM	1/13/85	Snow	3.60	0.375	CS
										8/28/85	Snow	3.51	0.586	CS
										1/06/91	Snow	1.93	0.408	CM
										1/13/96	Snow	2.97	0.397	PN

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska

[Field Notes, locator for observation notebook entries; abbreviation methods are explained in the Mass balance data section. Stake reading, *b′,* average height of the surface above a stake base within 3- to 5-m radius, measured by pocket tape; *b**, average surface height on a stake measured by surveying; *b***, average height on a leaning stake calculated (beginning in 1979) as the vertical distance between the stake base and the sloping glacier surface above it, and is the most accurate stake reading. *Stratum*, mass balance stratigraphic unit; Sice, superimposed ice; OFirn, old firn; SFirn, superimposed ice in old firn; NFirn, new firn. Snow Depth, *d*, measured vertically in pits and core holes and by probing. Average depth, *d*; standard error, *s.e.*; and number of observations, *n*, calculated from the pit, core, and probe data. Measured summer surface height between stratigraphic units, Obsvd. *b′ss*, is each stake reading minus the average snow or new firn depth at a pit or core hole measured at the same time. Average summer surface height at the stake, Average *b′ss*, is the average of the measured summer surfaces each season weighted by the number of measurements each observation. Old Firn and Ice Density, ρ, is estimated unless noted as measured. The water equivalent depth of old firn and ice above the stake base, *b′(i)*, is used to calculate the old firn and ice loss, $b_a(i)$, since the beginning of the hydrologic year. Snow and New Firn Depth, *d*, listed under Surface Mass Balance, is the difference between the most accurate stake reading, *b′, b**, or *b***, and the average summer surface height at the stake, Average *b′ss*. Snow and New Firn density, ρ, is measured, M; partially measured, m; or estimated, E; see Mass balance data section for methods. Surface Mass Balance Yearly Results, *b(i)*, old firn and ice balance after October 1; *b(s)*, snow balance; *b(f)*, either net or annual new firn balance; b_n, yearly net balance; and b_a, anual balance, are derived from the measurements and explained in the End-of-year estimates section and by Mayo and others, 1972. Measurement units are m/d/y, month/day/year, yr, year; m, meters; kg/L, kilograms per liter; m(w), meters water equivalant; ^{o}C, degrees Celsius; km, kilometers; g, grams; m^2, square meters; mm, millimeters; ----, no data available]

OBSERVATIONS											SURFACE MASS BALANCE								
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn			Yearly Results	
Field Notes	Date	Tape *b′*	Survey *b**	Survey *b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Obsvd. *b′ss*	Average *b′ss*	Density ρ	Stake *b′(i)*	Ice *b(i)*	Depth *d*	Density ρ		Snow *b(s)*	NFirn *b(f)*	Net *bn*	Annual *ba*
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1966 MEASUREMENT YEAR																					
		(Minimum balance) Date not known; no weather data at the glacier.																	0.00		----	----
	10/01/65	(Hydrologic year begins) Initial and final balance conditions of the hydrologic year not observed.													----				----		----	----
		First mass balance measurement at Wolverine Glacier.																				
		STAKE 66-3 (wood stake installed 4/23/66; flexible connection at 3-m joint)																				
M45A	4/23/66				Snow	1.60	1.58	1.58	0.03	3						1.58	0.473	M	0.75		----	----
		Snow listed above does not include a 0.03-m thick layer of transient superimposed ice at its base.																				
		8.05			SIce	0.03		0.03		1	8.02				----	0.03	0.90	E				
		Total of Snow and Superimposed Ice:				1.63		1.61				8.02	0.90	7.22	----	1.61	0.48	m	0.77		0.77	
M68A	6/19/66				Snow			0.05		1		8.02	0.90	7.22	----	0.05	0.60	E	0.03		0.03	----
		Observed "thin snow" at the stake.																				
M98A	9/03/66	4.00			Ice								0.90	3.60	----						-3.62	----
	9/30/66	(Hydrologic year ends)																	----			----
		(Minimum balance)			Date not known; no weather data at the glacier.									2.30					0.00		-4.92	
		Minimum balance estimate using observations of May 1967.																				
M154A	10/20/66	Stake buried.			Snow		0.50	0.50		1						0.50	0.30	E	0.15			
M81B	5/28/67	2.50			Ice								0.90	2.25								
M83A	5/30/67	2.46			Ice	2% remnant snow cover of area near stake.							0.90	2.21								

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS												SURFACE MASS BALANCE									
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results
Field Notes	Date	Tape b'	Survey b^*	b^{**}	*Stratum*	Pit/Core d	Probe d	Average d	*s.e.*	n	Obsvd. b'_{ss}	Average b'_{ss}	Density ρ	Stake $b'(i)$	Ice $b(i)$	Depth d	Density ρ		Snow $b(s)$	NFirn $b(f)$	Net bn	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1967 MEASUREMENT YEAR																					
		STAKE 66-3 (installed 4/23/66)																			
	10/01/66	(Hydrologic year begins)			Initial balance condition for the hydrologic year not observed.														----		----
	----	(Minimum balance)			Date not known; no weather data at the glacier.									2.30	----				0.00		0.00	----
M154A	10/20/66	Stake buried.			Snow		0.50	0.50		1				2.30	----	0.50	0.30	E	0.15		0.15	----
Map 67-1	4/01/67	Stake buried.			Snow		1.00	1.00		1				2.30	----	1.00	0.39	E	0.39		0.39	----
M80B	5/26/67	Stake not found.																				
M81B	5/28/67	2.50			Ice								0.90	2.25	----						-0.05	----
M83A	5/30/67	2.46			Ice	2% snow cover of area near stake.							0.90	2.21	----						-0.09	----
SHJ	8/02/67	Stake found fallen over.																				
		STAKE 67-4 (installed 5/30/67)												Ice balance continued from Stake 66-3.								
M83A	5/30/67	7.52			Ice								0.90	6.77	----						-0.09	----
SHJ	8/02/67	3.60			Ice								0.90	3.24	----						-3.62	----
M137C	9/18/67	2.25			Ice								0.90	2.03	----						-4.83	----
	9/30/67	(Hydrologic year ends)												1.91	----				0.00		-4.95	----
Photo	10/04/67				Snow			0.10		1				1.88		0.10	0.30	E	0.03		-4.95	
						Thin snow observed from aircraft.																
	10/14/67	(Minimum balance)												1.77					0.00		-5.09	
M66C	6/07/68	2.80			Snow			0.83		1.97		1.97	0.90	1.77		0.83	0.55	E	0.46			
						Snow depth measured at nearby Stake 68-4A.																

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	*b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Obsvd. *b'ss*	Average *b'ss*	Density *ρ*	Stake *b'(i)*	Ice *b(i)*	Depth *d*	Density *ρ*	Snow *b(s)*	NFirn *b(f)*	Net *bn*	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L	m(w)	m(w)	m(w)	m(w)
													1968 MEASUREMENT YEAR								
		STAKE 67-4 (installed 5/30/67)																			
M137C	9/18/67	2.25			Ice								0.90	2.03							
	10/01/67	(Hydrologic year begins)												1.91	0.00			0.00			0.00
Photo	10/04/67				Snow			0.10		1		2.09	0.90	1.88	-0.03	0.10	0.30 E	0.03			0.03
								Thin snow at site observed from aircraft.													
	10/14/67	(Minimum balance)												1.77	-0.14			0.00		0.00	-0.14
M9C	3/31/68				Snow		1.90	1.90	0.00	2		1.97	0.90	1.77	-0.14	1.90	0.40 E	0.76		0.76	0.62
M66C	6/07/68	2.80			Snow			0.83			1.97	1.97	0.90	1.77	-0.14	0.83	0.55 E	0.46		0.46	0.32
						Snow depth observation at nearby Stake 68-4A.															
		STAKE 68-4 (installed 4/04/68 in a snow pit.)																			
	10/01/67	(Hydrologic year begins)													0.00			0.00			0.00
Photo	10/04/67				Thin snow observed.			0.10		1					-0.03	0.10	0.30 E	0.03			
													Ice balance continued from Stake 67-4.								
	10/14/67	(Minimum balance)										5.52	0.90	4.97	-0.14			0.00		0.00	-0.14
M9C	3/31/68				Snow		1.90	1.90	0.00	2		5.52	0.90	4.97	-0.14	1.90	0.40 E	0.76		0.76	0.62
M12A	4/04/68	7.73			Snow	2.52	2.18	2.21	0.06	12	5.52	5.52	0.90	4.97	-0.14	2.21	0.397 M	0.88		0.88	0.74
		5.21			Ice																
		Stake observed in snow pit.																			
M79C	7/18/68	3.80			Ice								0.90	3.42	-1.69					-1.55	-1.69
M87A	8/20/68	2.10			Ice								0.90	1.89	-3.22					-3.08	-3.22
	9/29/68	(Minimum balance)												1.08	-4.03			0.00		-3.89	-4.03
	9/30/68	(Hydrologic year ends)												1.08	-4.03			0.01			-4.02
M108D	10/06/68	1.22			Snow		0.02	0.02		1	1.20	1.20	0.90	1.08		0.02	0.30 E	0.01			
M109D	10/09/68				Snow			0.01		1						0.01	0.30 E	0.003			
								Thin snow observed.													
M4D	1/28/69	1.80			Snow	0.60		0.60		1	1.20	1.20	0.90	1.08		0.60	0.361 M	0.22			
		STAKE 68-4A (installed 4/04/68, inserted in snow to ice)											Ice balance continued from Stake 67-4.								
M12A	4/04/68	2.02			Snow	2.52	2.18	2.21	0.06	12	-0.19	-0.19	0.90	-0.17	-0.14	2.21	0.397 M	0.88		0.88	0.74
M14A	4/06/68	2.04			Snow							-0.19	0.90	-0.17	-0.14	2.23	0.40 E	0.89		0.89	0.75
M16F	4/07/68	2.06			Snow							-0.19	0.90	-0.17	-0.14	2.25	0.40 E	0.90		0.90	0.76
M65F	6/07/68	0.64			Snow							-0.19	0.90	-0.17	-0.14	0.83	0.55 E	0.46		0.46	0.32
	7/18/68	(Stake found fallen over)																			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1969 MEASUREMENT YEAR											
		STAKE 68-4 (installed 4/04/68)																				
M87A	8/20/68	2.10			Ice								0.90	1.89								
	9/29/68	(Minimum balance)												1.08					0.00		0.00	
	10/01/68	(Hydrologic year begins)												1.08	0.00				0.01		0.01	0.00
M108D	10/06/68	1.22			Snow		0.02	0.02		1	1.20	1.20	0.90	1.08	0.00	0.02	0.30	E	0.01		0.01	0.00
M109D	10/09/68				Snow		0.02	0.02		1		1.20	0.90	1.08	0.00	0.02	0.30	E	0.01		0.01	0.00
M4D	1/28/69	1.80			Snow	0.60		0.60		1	1.20	1.20	0.90	1.08	0.00	0.60	0.361	M	0.22		0.22	0.21
M12A	4/13/69				Snow	1.69		1.69		1		1.20	0.90	1.08	0.00	1.69	0.364	M	0.62		0.62	0.61
M67B	6/06/69	2.15			Snow							1.20	0.90	1.08	0.00	0.95	0.46	E	0.44		0.44	0.43
M81C	8/02/69	Stake found melted out.																			<-1.08	<-1.09
		STAKE 69-4 (installed 8/02/69)											Ice balance continued from Stake 68-4.									
M81C	8/02/69	3.20			Ice								0.90	2.88	<-1.08						<-1.08	<-1.09
M105A	9/16/69	1.29			Ice								0.90	1.16	<-2.08						<-2.08	<-2.09
	9/30/69	(Hydrologic year ends)																	0.00		---	---
	10/31/69	(Minimum balance)																			---	
	11/19/69				Ice (Observed from aircraft)																	
M112B	11/23/69	0.70			Snow		0.10	0.10	---	10	0.60	0.60	0.90	0.54	<-3.42	0.10	0.30	E	0.03		<-3.42	<-3.42
		STAKE 69-4A (installed 10/06/68)																				
	9/29/68	(Minimum balance)																	0.00		0.00	
	10/01/68	(Hydrologic year begins)												1.13	0.00				0.01		0.01	0.00
M108D	10/06/68	1.07			Snow		0.02	0.02		1	1.05	1.26	0.90	1.13	0.00	0.02	0.30	E	0.01		0.01	0.00
M4D	1/28/69	1.80			Snow	0.60		0.60		1	1.20	1.26	0.90	1.13	0.00	0.54	0.361	M	0.19		0.19	0.18
M12A	4/13/69	3.23			Snow	1.69		1.69		1	1.54	1.26	0.90	1.13	0.00	1.97	0.364	M	0.72		0.72	0.71
M67B	6/06/69	1.95			Snow							1.26	0.90	1.13	0.00	0.69	0.46	E	0.32		0.32	0.31
M81C	8/02/69	Stake not found.																			<-1.23	<-1.24
	9/30/69	(Hydrologic year ends)																	0.00		---	---
	10/31/69	(Minimum balance)																			---	

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	*b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Obsvd. *b'ss*	Average *b'ss*	Density *ρ*	Stake *b'(i)*	Ice *b(i)*	Depth *d*	Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Net *bn*	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1970 MEASUREMENT YEAR																						
		STAKE 69-4 (installed 8/02/69)																				
69M105A	9/16/69	1.29			Ice								0.90	1.16								
	10/01/69	(Hydrologic year begins)												0.87	0.00				0.00			0.00
	10/31/69	(Minimum balance)												0.54	-0.33				0.00		0.00	-0.33
Form	11/19/69				Ice (Observed from aircraft)									0.54	-0.33				0.00		0.00	-0.33
M112B	11/23/69	0.70			Snow		0.10	0.10	----	10	0.60	0.60	0.90	0.54	-0.33	0.10	0.30	E	0.03		0.03	-0.30
M40D	7/22/70	0.55			Ice	20% snow cover. Stake broken at 0.6 m, probable ice top during previous winter.							0.90	0.50	-0.37						-0.04	-0.37
		STAKE 70-4 (installed 4/18/70)											Ice balance continued from Stake 69-4.									
M23H,Z9A	4/18/70	11.00			Snow	3.45	3.57	3.56	0.02	9	7.44	7.44	0.90	6.70	-0.33	3.56	0.432	M	1.54		1.54	1.21
Z21B	6/10/70	9.34			Snow	1.86		1.86		1	7.48	7.44	0.90	6.70	-0.33	1.90	0.535	M	1.02		1.02	0.69
Z23B	6/11/70	9.30			Snow							7.44	0.90	6.70	-0.33	1.86	0.54	E	1.00		1.00	0.67
M40D	7/22/70	7.20			Ice								0.90	6.48	-0.55						-0.22	-0.55
M75G	9/27/70	4.70			Ice								0.90	4.23	-2.80						-2.47	-2.80
	9/30/70	(Hydrologic year ends)												4.20	-2.83				0.00		-2.50	-2.83
M82D	10/03/70	4.65			Ice								0.90	4.19							-2.51	
	10/13/70	(Minimum balance)												4.07					0.00		-2.63	
M2C	1/09/71	5.34			Snow	0.79		0.79		1	4.55	4.52	0.90	4.07		0.82	0.291	M	0.24			
						0.02 m superimposed ice observed at pit.																
M62C	7/09/71	4.99			Slush		0.50	0.50		1	4.49	4.52	0.90	4.07		0.47	0.90	E	0.42			
		STAKE 70-4A (installed 9/16/69; metal conduit without wood plug in base)																				
M105A	9/16/69	1.52			Ice								0.90	1.37								
Airplane	11/19/69				Ice	Observation from aircraft.																
M112B	11/23/69	2.29			Snow		0.10	0.10	----	10	2.19	2.30	0.90	2.07		0.10	0.30	E	0.03		0.03	
M23,24,Z9	4/18/70	5.97			Snow	3.45	3.57	3.56	0.02	9	2.41	2.30	0.90	2.07		3.67	0.432	M	1.59		1.59	
Z21B,22	6/10/70	4.16			Snow	1.86		1.86		1	2.30	2.30	0.90	2.07		1.86	0.535	M	1.00		1.00	
		Stake leaning ~30 degrees; snow depth measured at snow pit.																				

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape b′	Survey b*	Survey b**	Stratum	Pit/Core d	Probe d	Average d	s.e.	n	Summer Surface Obsvd. b′ss	Summer Surface Average b′ss	Old Firn and Ice Density ρ	Old Firn and Ice Stake b′(i)	Old Firn and Ice Ice b(i)	Snow and New Firn Depth d	Snow and New Firn Density ρ		Snow b(s)	NFirn b(f)	Yearly Results Net bn	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1971 MEASUREMENT YEAR											
		STAKE 70-4 (installed 4/18/70)																				
M75G	9/27/70	4.70			Ice								0.90	4.23								
	10/01/70	(Hydrologic year begins)												4.20	0.00				0.00			0.00
M82D	10/03/70	4.65			Ice								0.90	4.19	-0.01							-0.01
	10/13/70	(Minimum balance)												4.07	-0.13				0.00		0.00	-0.13
M2C	1/09/71	5.34			Snow	0.79		0.79		1	4.55	4.52	0.90	4.07	-0.13	0.82	0.291	M	0.24		0.24	0.11
					0.02 m superimposed ice at base of snow.																	
M33C	4/27/71	Stake buried.			Snow	2.46	2.37	2.38	0.02	11					-0.13	2.38	0.365	M	0.87		0.87	0.74
M36G	5/03/71	Stake buried.			Snow	0.37		0.37		1					-0.13	0.37	0.30	E	0.11		0.11	-0.02
					0.37 m new snow after 4/27/71.																	
M62C	7/09/71	4.99			Slush		0.50	0.50		1	4.49	4.52	0.90	4.07	-0.13	0.47	0.90	E	0.42		0.42	0.29
M77A	8/14/71	3.00			Ice								0.90	2.70	-1.63						-1.37	-1.63
	9/30/71	(Hydrologic year ends)			Final balance conditions not known; no weather data at the glacier.																	----
	----	(Minimum balance)			Date not known; no weather data at the glacier.							1.52	0.90	1.37					0.00		-2.70	
M103B	10/17/71	1.86			Snow		0.43	0.43		1	1.43	1.52	0.90	1.37		0.34	0.31	E	0.11			
											1972 MEASUREMENT YEAR											
		STAKE 70-4 (installed 4/18/70)																				
	10/01/71	(Hydrologic year begins)			Initial balance conditions unknown, no weather data.									0.00								----
	----	(Minimum balance)			Date not known; no weather data at the glacier.									1.37	----				0.00		0.00	----
M103B	10/17/71	1.86			Snow		0.43	0.43		1	1.43	1.52	0.90	1.37	----	0.34	0.31	E	0.11		0.11	----
M2B	1/11/72	1.82			Snow	0.41		0.41		1	1.41	1.52	0.90	1.37	----	0.30	0.345	M	0.10		0.10	----
M8J	4/08/72	1.88			Snow	0.21	0.35	0.34	0.05	11	1.54	1.52	0.90	1.37	----	0.36	0.336	M	0.12		0.12	----
M36C	6/19/72	0.80			Ice								0.90	0.72	----						-0.65	----
					Stake is frozen in.																	
		STAKE 72-4 (installed 4/11/72; unlabeled)											Ice balance continued from Stake 70-4.									
M13Y	4/11/72	9.90			Snow		0.35	0.35		1	9.55	9.55	0.90	8.60	----	0.35	0.38	E	0.13		0.13	----
M36C	6/19/72	9.00			Ice								0.90	8.10	----						-0.50	----
M42C	7/12/72	7.78			Ice								0.90	7.00	----						-1.60	----
M61I	8/19/72	6.00			Ice								0.90	5.40	----						-3.20	----
	9/29/72	(Minimum balance)												4.30	----						-4.30	----
	9/30/72	(Hydrologic year ends)												4.30	----				0.003			----
M66D	10/01/72	4.65			Snow		0.01	0.01		1	4.64	4.78	0.90	4.30		0.01	0.30	E	0.003			
M2B	1/06/73	5.57			Snow	0.83	0.78	0.78	0.04	11	4.79	4.78	0.90	4.30		0.79	0.296	M	0.23			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS												SURFACE MASS BALANCE									
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field Notes	Date	Tape b'	Survey b^*	b^{**}	*Stratum*	Pit/Core d	Probe d	Average d	*s.e.*	n	Obsvd. $b'ss$	Average $b'ss$	Density ρ	Stake $b'(i)$	Ice $b(i)$	Depth d	Density ρ		Snow $b(s)$	NFirn $b(f)$	Net bn	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1973 MEASUREMENT YEAR																					
		STAKE 72-4 (installed 4/11/72)																			
M61I	8/19/72	6.00			Ice								0.90	5.40							
	9/29/72	(Minimum balance)																		0.00	
	10/01/72	(Hydrologic year begins)													0.00				0.003	0.003	
M66D	10/01/72	4.65			Snow		0.01	0.01		1	4.64	4.78	0.90	4.30	0.00	0.01	0.30	E	0.003	0.003	0.00
M2B	1/06/73	5.57			Snow	0.83	0.78	0.78	0.04	11	4.79	4.78	0.90	4.30	0.00	0.79	0.296	M	0.23	0.23	0.23
M21.5C	4/19/73	Stake buried.			Snow	2.13	2.21	2.20	0.05	9					0.00	2.20	0.341	M	0.75	0.75	0.75
M29B	5/31/73	Stake buried.			Snow		1.65	1.65	0.00	2					0.00	1.65	0.46	E	0.76	0.76	0.76
M32E	7/07/73	4.60			Ice								0.90	4.14	-0.16					-0.16	-0.16
M53A	8/25/73	1.64			Ice								0.90	1.48	-2.82					-2.82	-2.82
		STAKE 73-4 (installed 8/25/73)																			
													Ice balance continued from Stake 72-4.								
M53F	8/25/73	1.80			Ice								0.90	1.62	-2.82					-2.82	-2.82
	9/30/73	(Hydrologic year ends)												0.85	-3.59				0.00	-3.59	-3.59
	10/01/73	(Minimum balance)												0.85	-3.59				0.00	-3.59	
M60B	10/15/73	1.00			Snow		0.08	0.08		1	0.92	0.94	0.90	0.85		0.06	0.30	E	0.02		
M24B	6/09/74	0.98			SIce	0.03		0.03		1	0.95	0.94	0.90	0.85		0.04	0.90	E	0.04		

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1974 MEASUREMENT YEAR																						
		STAKE 73-4 (installed 8/25/73)																				
M53F	8/25/73	1.80			Ice								0.90	1.62								
	10/01/73	(Hydrologic year begins and minimum balance)												0.85	0.00				0.00		0.00	0.00
M60B	10/15/73	1.00			Snow		0.08	0.08		1	0.92	0.94	0.90	0.85	0.00	0.06	0.30	E	0.02		0.02	0.02
T3A	3/09/74				Snow	0.98		0.98		1					0.00	0.98	0.338	M	0.33		0.33	0.33
T5G	3/10/74	1.90			Snow							0.94	0.90	0.85	0.00	0.96	0.34	E	0.33		0.33	0.33
M24B	6/09/74	0.98			SIce	0.03		0.03			0.95	0.94	0.90	0.85	0.00	0.04	0.90	E	0.04		0.04	0.04
	9/30/74	(Hydrologic year ends and minimum balance)																	0.00		----	----
T6	2/08/75	0.40			Ice						Stake sank into the ice.										----	----
AST TO A LOCATION ON THE LONGITUDINAL CENTERLINE OF THE GLACIEI																						
		STAKE 74-4 (installed 6/09/74)											Ice balance continued from stake 73-4.									
M24G	6/09/74	4.24			SIce	0.03		0.03		1	4.21	4.21	0.90	3.79	0.00	0.03	0.90	E	0.03		0.03	0.03
		Auger drill hole dry; therefore, ice is colder than 0C.																				
T43A	8/04/74	1.15			Ice								0.90	1.04	-2.75						-2.75	-2.75
		Stake reset																				
T43A	8/04/74	3.13			Ice								0.90	2.82	-2.75						-2.75	-2.75
M49I	9/22/74	0.50			Ice								0.90	0.45	-5.12						-5.12	-5.12
	9/30/74	(Hydrologic year ends and minimum balance)												0.36	-5.21				0.00		-5.21	-5.21
T5A	2/08/75	0.40			Ice	1.60	1.53	1.55	0.10	3			0.90	0.36		1.55	0.377	M	0.58			
		Stake reading of ice surface made by digging to the surface.																				
1975 MEASUREMENT YEAR																						
		STAKE 75-A (installed 2/08/75)																				
	10/01/74	(Hydrologic year begins and minimum balance)												5.62	0.00				0.00		0.00	0.00
T5A	2/08/75	7.79			Snow	1.60	1.53	1.55	0.10	3	6.24	6.24	0.90	5.62	0.00	1.55	0.377	M	0.58		0.58	0.58
M8D	5/31/75	7.55			Snow							6.24	0.90	5.62	0.00	1.31	0.45	E	0.59		0.59	0.59
M21A	8/17/75	3.50			Ice								0.90	3.15	-2.47						-2.47	-2.47
		Stake removed.																				
		STAKE 75-A2 (installed 2/08/75)											Ice balance continued from Stake 75-A.									
T5A	2/08/75	12.20			Snow	1.60	1.53	1.55	0.10	3	10.65	10.65	0.90	9.59	0.00	1.55	0.377	M	0.58		0.58	0.58
M8D	5/31/75	Stake buried.																				
M21A	8/17/75	8.50			Ice								0.90	7.65	-1.94						-1.94	-1.94
T33C	8/20/75	8.45			Ice								0.90	7.61	-1.98						-1.98	-1.98
	9/30/75	(Hydrologic year ends)												5.59	-4.00				0.00		-4.00	-4.00
	10/08/75	(Minimum balance)												5.32	-4.27				0.00		-4.27	
M44A	10/25/75	6.11			Snow		0.20	0.20		1	5.91	5.91	0.90	5.32		0.20	0.30	E	0.06			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1976 MEASUREMENT YEAR																						
		STAKE 75-A2 (installed 2/08/75)																				
T33C	8/20/75	8.45			Ice								0.90	7.61								
	10/01/75	(Hydrologic year begins)												5.59	0.00				0.00			0.00
	10/08/75	(Minimum balance)												5.32	-0.27				0.00		0.00	-0.27
M44A	10/25/75	6.11			Snow		0.20	0.20		1	5.91	5.91	0.90	5.32	-0.27	0.20	0.30	E	0.06		0.06	-0.21
	1/23/76	Augustine volcano began erupting; ashfall on Wolverine Glacier.																				
M8A	2/25/76	No stake reading.			Snow	0.83	1.29	1.26	0.11	18		5.91	0.90	5.32	-0.27	1.26	0.375	M	0.47		0.47	0.20
		Pit to ice; no volcanic ash found.																				
M30E	7/10/76	4.65			Ice								0.90	4.19	-1.40						-1.13	-1.40
T22A	7/12/76	4.53			Ice								0.90	4.08	-1.51						-1.24	-1.51
	9/27/76	(Minimum balance)												0.72	-4.87				0.00		-4.60	-4.87
	9/30/76	(Hydrologic year ends)													-4.87				0.04			-4.83
T34	10/19/76	0.90			Snow		0.10	0.10		1	0.80	0.80	0.90	0.72		0.10	0.60	E	0.06			
		Stake found leaning badly, propped up.															Density estimated visually.					
1977 MEASUREMENT YEAR																						
		STAKE 77-A (installed 2/22/77; metal conduit without wood plug in base)																				
	9/27/76	(Minimum balance)																	0.00		0.00	
	10/01/76	(Hydrologic year begins)													0.00				0.04		0.04	0.00
T3A	2/22/77	5.17			Snow	5.06	4.90	4.91	0.07	11	0.26	0.26			0.00	4.91	0.539	M	2.65		2.65	2.61
T4A	2/23/77	Stake not read.			Snow		4.71	4.71	0.07	10		0.26			0.00	4.71	0.54	E	2.54		2.54	2.50
M30A	6/06/77	5.44			Snow		3.83	3.83	0.09	4	1.61	1.61			0.00	3.83	0.54	E	2.07		2.07	2.03
T34A	6/10/77	5.30			Snow	3.33		3.33		1	1.97	1.97			0.00	3.33	0.610	M	2.03		2.03	1.99
											Stake sank 1.67 m into the ice; the stake readings are not valid for ice balance data.											
		STAKE 77-A2 (installed 6/06/77)											Ice balance continued from Stake 77-A.									
	9/27/76	(Minimum balance)												6.36					0.00		0.00	
	10/01/76	(Hydrologic year begins)												6.36	0.00				0.04		0.04	0.00
M30A	6/06/77	10.75			Snow		3.71	3.71	0.08	5	7.04	7.07	0.90	6.36	0.00	3.68	0.54	E	1.99		1.99	1.95
T34A	6/10/77	10.55			Snow	3.33		3.33		1	7.22	7.07	0.90	6.36	0.00	3.48	0.610	M	2.12		2.12	2.08
		Snow wet to bottom, no superimposed ice.																				
	9/30/77	(Hydrologic year ends)												3.47	-2.89				0.00		-2.89	-2.93
	10/14/77	(Minimum balance)												3.17					0.00		-3.19	
T98A	10/24/77	4.13			Snow	0.33	0.47	0.46	0.07	14	3.67	3.52	0.90	3.17		0.61	0.31	E	0.19			
		3.80			Ice	Pit at the stake.					See 1978 measurement year for average *b'ss*.											

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)		m(w)	m(w)
													1978 MEASUREMENT YEAR									
		STAKE 77-A2 (installed 6/06/77)																				
	10/01/77	(Hydrologic year begins)												3.47	0.00				0.00			0.00
	10/14/77	(Minimum balance)												3.17	-0.30				0.00		0.00	-0.30
T98A	10/24/77	4.13			Snow	0.33	0.47	0.46	0.07	14	3.67	3.52	0.90	3.17	-0.30	0.61	0.31	E	0.19		0.19	-0.11
		3.80			Ice	Pit at the stake.																
M3A	3/01/78	6.55			Snow							3.52	0.90	3.17	-0.30	3.03	0.39	E	1.18		1.18	0.88
T7A	3/02/78	6.52			Snow	3.00	3.18	3.17	0.13	12	3.35	3.52	0.90	3.17	-0.30	3.00	0.389	M	1.17		1.17	0.87
M26A	6/04/78	5.32			Snow							3.52	0.90	3.17	-0.30	1.80	0.49	E	0.88		0.88	0.58
T108	9/28/78	Stake found fallen over.																				
		STAKE 78-6.9A (installed 3/02/78)											Ice balance continued from Stake 77-A2.									
T7A	3/02/78	10.77			Snow	3.00	3.18	3.17	0.13	12	7.60	7.60	0.90	6.84	-0.30	3.17	0.389	M	1.23		1.23	0.93
M26A	6/04/78	9.53			Snow							7.60	0.90	6.84	-0.30	1.93	0.49	E	0.95		0.95	0.65
T108	9/28/78	3.40			Ice								0.90	3.06	-4.08						-3.78	-4.08
		Stake reset.																				
T108	9/28/78	1.40			Ice								0.90	1.26	-4.08						-3.78	-4.08
	9/30/78	(Hydrologic year ends)												1.24	-4.10				0.00		-3.80	-4.10
	10/18/78	(Minimum balance)												1.16					0.00		-3.88	
M3B	3/11/79	3.19			Snow		1.90	1.90	0.09	10	1.29	1.29	0.90	1.16		1.90	0.38	E	0.72			
		STAKE 78-6.9A2 (installed 3/02/78)											Ice balance continued from Stake 77-A2.									
T7	3/02/78	10.06			Snow	3.00	3.18	3.17	0.13	12	6.89	6.89	0.90	6.20	-0.30	3.17	0.389	M	1.23		1.23	0.93
M26A	6/04/78	8.80			Snow							6.89	0.90	6.20	-0.30	1.91	0.49	E	0.94		0.94	0.64
T108	9/28/78	2.73			Ice								0.90	2.46	-4.04						-3.74	-4.04
		Stake removed; balance at end of year estimated from balances measured at other stakes.																				
	9/30/78	(Hydrologic year ends)																	0.00		-3.76	-4.06
	10/18/78	(Minimum balance)																	0.00		-3.84	
																				Average of 2 stakes:	-3.86	-4.08

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Stake Reading: Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Snow Depth: Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface: Obsvd. *b'ss*	Average *b'ss*	Old Firn and Ice: Density *ρ*	Stake *b'(i)*	Ice *b(i)*	Snow and New Firn: Depth *d*	Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results: Net *bn*	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1979 MEASUREMENT YEAR																						
		STAKE 78-6.9A (installed 3/02/78)																				
T108	9/28/78	1.40			Ice								0.90	1.26								
	10/01/78	(Hydrologic year begins)												1.24	0.00				0.00			0.00
	10/18/78	(Minimum balance)												1.16	-0.08				0.00		0.00	-0.08
M3B	3/11/79	3.19			Snow		1.90	1.90	0.09	10	1.29	1.29	0.90	1.16	-0.08	1.90	0.38	E	0.72		0.72	0.64
M6B	3/14/79		3.40	3.20	Snow							1.29	0.90	1.16	-0.08	1.91	0.38	E	0.73		0.73	0.65
	NOTES:	STAKE SURVEYS OF *b** and *b*** BEGAN AT WOLVERINE GLACIER IN 1979																				
		STAKE READINGS LISTED AS *b** ARE SURVEYED; THOSE LISTED AS *b*** ARE SURVEYED AND CORRECTED FOR STAKE LEAN.																				
		STAKE 79-6.9A (installed 3/11/79)																				
	10/01/78	(Hydrologic year begins)												7.62	0.00				0.00			0.00
													Ice balance continued from Stake 78-6.9A.									
	10/19/78	(Minimum balance)												7.54	-0.08				0.00		0.00	-0.08
M3B	3/11/79	10.28			Snow		1.90	1.90	0.09	10	8.38	8.38	0.90	7.54	-0.08	1.90	0.38	E	0.72		0.72	0.64
M5A	3/14/79		10.46	10.40	Snow							8.38	0.90	7.54	-0.08	2.02	0.39	E	0.79		0.79	0.71
M105	8/11/79	4.40			Ice								0.90	3.96	-3.66						-3.58	-3.66
	9/30/79	(Hydrologic year ends)												1.95	-5.67				0.00		-5.59	-5.67
	10/27/79	(Minimum balance)												1.65					0.00		-5.89	
T4	1/11/80	3.18			Snow		1.35	1.35	0.08	10	1.83	1.83	0.90	1.65		1.35	0.34	E	0.46			
1980 MEASUREMENT YEAR																						
		STAKE 79-6.9A (installed 3/11/79)																				
M105	8/11/79	4.40			Ice								0.90	3.96								
	10/01/79	(Hydrologic year begins)												1.95	0.00				0.00			0.00
	10/27/79	(Minimum balance)												1.65	-0.30				0.00		0.00	-0.30
T4	1/11/80	3.18			Snow		1.35	1.35	0.08	10	1.83	1.83	0.90	1.65	-0.30	1.35	0.34	E	0.46		0.46	0.16
M37	6/04/80	5.17		5.09	Snow							1.83	0.90	1.65	-0.30	3.26	0.50	E	1.63		1.63	1.33
		STAKE 80-A (installed 1/11/80)											Ice balance continued from Stake 79-6.9A.									
T4	1/11/80	10.90			Snow		1.35	1.35	0.08	10	9.55	9.55	0.90	8.60	-0.30	1.35	0.34	E	0.46		0.46	0.16
M37	6/04/80	12.80*			Snow		* b' estimate because stake was burried								-0.30	3.25	0.50	E	1.63		1.63	1.33
M82	9/02/80		8.44	8.14	Ice								0.90	7.33	-1.57						-1.27	-1.57
M89	9/09/80	8.00			Ice								0.90	7.20	-1.70						-1.40	-1.70
	9/30/80	(Hydrologic year ends)												6.74	-2.16				0.00		-1.86	-2.16
	10/07/80	(Minimum balance)												6.64					0.00		-1.96	
T5	1/22/81	9.15			Snow		1.77	1.77	0.05	20	7.38	7.38	0.90	6.64		1.77	0.35	E	0.62			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density ρ	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density ρ		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1981 MEASUREMENT YEAR																						
		STAKE 80-A (installed 1/11/80)																				
M89	9/09/80	8.00			Ice								0.90	7.20								
	10/01/80	(Hydrologic year begins)												6.74	0.00				0.00			0.00
	10/07/80	(Minimum balance)												6.64	-0.10				0.00		0.00	-0.10
T5	1/22/81	9.15			Snow		1.77	1.77	0.05	20	7.38	7.38	0.90	6.64	-0.10	1.77	0.35	E	0.62		0.62	0.52
M4	1/26/81			9.58	Snow							7.38	0.90	6.64	-0.10	2.20	0.36	E	0.79		0.79	0.69
RM12	6/02/81			9.64	Snow							7.38	0.90	6.64	-0.10	2.26	0.50	E	1.13		1.13	1.03
RM31	9/01/81	5.15			Ice								0.90	4.64	-2.10						-2.00	-2.10
T101	9/01/81		5.11	5.14	Ice								0.90	4.63	-2.11						-2.01	-2.11
	9/30/81	(Hydrologic year ends)												4.11	-2.63				0.00		-2.53	-2.63
	10/17/81	(Minimum balance)												3.99					0.00		-2.65	
M8	1/20/82	5.45			Snow		1.02	1.02	0.01	5	4.43	4.43	0.90	3.99		1.02	0.33	E	0.34			
1982 MEASUREMENT YEAR																						
		STAKE 80-A (installed 1/11/80)																				
T101	9/01/81			5.14	Ice								0.90	5.14								
	10/01/81	(Hydrologic year begins)												4.11	0.00				0.00			0.00
	10/17/81	(Minimum balance)												3.99	-0.12				0.00		0.00	-0.12
M8	1/20/82	5.45			Snow		1.02	1.02	0.01	5	4.43	4.43	0.90	3.99	-0.12	1.02	0.33	E	0.34		0.34	0.22
M11	1/22/82			5.40	Snow							4.43	0.90	3.99	-0.12	0.97	0.33	E	0.32		0.32	0.20
M37	6/25/82	3.81		3.85	Ice								0.90	3.47	-0.64						-0.52	-0.64
		STAKE 82-A (installed 6/25/82)											Ice balance continued from Stake 80-A.									
M37	6/25/82			7.14	Ice								0.90	6.43	-0.64						-0.52	-0.64
M97	8/31/82			3.30	Ice								0.90	2.97	-4.10						-3.98	-4.10
M109	9/02/82	3.25	3.29	3.33	Ice								0.90	3.00	-4.07						-3.95	-4.07
	9/30/82	(Hydrologic year ends)												2.26	-4.81				0.00		-4.69	-4.81
	10/02/82	(Minimum balance)												2.25					0.00		-4.70	
T54	11/06/82	3.00			Snow		0.47	0.47	0.03	10	2.53	2.50	0.90	2.25		0.50	0.31	E	0.16			
												See 1983 measurement year for average *b'ss*.										

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
													1983 MEASUREMENT YEAR									
		STAKE 82-A (installed 6/25/82)																				
M109	9/02/82	3.25	3.29	3.33	Ice								0.90	3.00								
	10/01/82	(Hydrologic year begins)												2.26	0.00				0.00			0.00
	10/02/82	(Minimum balance)												2.25	-0.01				0.00		0.00	-0.01
T54	11/06/82	3.00			Snow		0.47	0.47	0.03	10	2.53	2.50	0.90	2.25	-0.01	0.50	0.31	E	0.16		0.16	0.15
M7	1/10/83	4.09			Snow		1.62	1.62	0.15	3	2.47	2.50	0.90	2.25	-0.01	1.59	0.33	E	0.52		0.52	0.51
T10	1/14/83			4.11	Snow							2.50	0.90	2.25	-0.01	1.61	0.35	E	0.56		0.56	0.55
M21	6/11/83			3.26	Snow		0.78	0.78	0.10	10	2.48	2.50	0.90	2.25	-0.01	0.76	0.46	E	0.35		0.35	0.34
		STAKE 83-A (installed 6/11/83)											Ice balance continued from Stake 82-A.									
M22	6/11/83	8.13		8.10	Snow		0.78	0.78	0.10	10	7.32	7.32	0.90	6.59	-0.01	0.78	0.46	E	0.36		0.36	0.35
		Stake sitting on connector at 3 m, 0.10 m excess length; corrections made.																				
M62	9/02/83			3.53	Ice								0.90	3.18	-3.42						-3.41	-3.42
	9/30/83	(Hydrologic year ends)												2.48	-4.12				0.00		-4.11	-4.12
	10/05/83	(Minimum balance)												2.40					0.00		-4.19	
													1984 MEASUREMENT YEAR									
		STAKE 83-A (installed 6/11/83)																				
M62	9/02/83			3.53	Ice								0.90	3.18								
	10/01/83	(Hydrologic year begins)												2.48	0.00				0.00			0.00
	10/05/83	(Minimum balance)												2.40	-0.08				0.00		0.00	-0.08
M66	11/14/83	3.55			Snow		0.73	0.73	0.02	3	2.82	2.67	0.90	2.40	-0.08	0.88	0.31	E	0.27		0.27	0.19
M6	1/18/84		4.49	4.42	Snow							2.67	0.90	2.40	-0.08	1.75	0.36	E	0.63		0.63	0.55
M12	1/21/84	4.45			Snow							2.67	0.90	2.40	-0.08	1.78	0.36	E	0.64		0.64	0.56
		Stake connector nested, lowered 0.13 m.																				
T26	6/07/84	3.44			Snow							2.67	0.90	2.40	-0.08	0.77	0.45	E	0.35		0.35	0.27
M23	6/10/84	3.30	3.29	3.24	Snow		0.72	0.72	0.05	11	2.52	2.67	0.90	2.40	-0.08	0.57	0.45	E	0.26		0.26	0.18
		Stake found with only 3-m and 9-m sections; 6-m section missing. Corrections applied to values recorded in field notes.																				
		STAKE 84-A (installed 6/10/84)											Ice balance continued from Stake 83-A.									
M24	6/10/84	9.30		9.27	Snow			0.57			8.70	8.70	0.90	7.83	-0.08	0.57	0.45	E	0.26		0.26	0.18
								Snow depth measured at Stake 83-A.														
M38	8/17/84			4.83	Ice								0.90	4.35	-3.56						-3.48	-3.56
	9/30/84	(Hydrologic year ends)												2.71	-5.20				0.00		-5.12	-5.20
	10/11/84	(Minimum balance)												2.51					0.00		-5.32	
RM84	10/30/84	2.80			Snow		0.01	0.01		1	2.79	2.79	0.90	2.51		0.01	0.30	E	0.003			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Stake Reading: Tape *b′*	Stake Reading: Survey *b**	Stake Reading: Survey *b***	Stratum	Snow Depth: Pit/Core *d*	Snow Depth: Probe *d*	Snow Depth: Average *d*	Snow Depth: *s.e.*	Snow Depth: *n*	Summer Surface: Obsvd. *b′ss*	Summer Surface: Average *b′ss*	Old Firn and Ice: Density *ρ*	Old Firn and Ice: Stake *b′(i)*	Old Firn and Ice: Ice *b(i)*	Snow and New Firn: Depth *d*	Snow and New Firn: Density *ρ*		Yearly Results: Snow *b(s)*	Yearly Results: NFirn *b(f)*	Yearly Results: Net *bn*	Yearly Results: Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1985 MEASUREMENT YEAR												
		STAKE 84-A (installed 6/10/84)																				
M38	8/17/84			4.83	Ice								0.90	4.35								
	10/01/84	(Hydrologic year begins)												2.71	0.00				0.00			0.00
	10/11/84	(Minimum balance)												2.51	-0.20				0.00		0.00	-0.20
RM84	10/30/84	2.80			Snow	0.01	0.01			1	2.79	2.79	0.90	2.51	-0.20	0.01	0.30	E	0.003		0.003	-0.20
RM8	1/12/85		4.47	4.33	Snow							2.79	0.90	2.51	-0.20	1.54	0.35	E	0.54		0.54	0.34
M38	6/08/85		4.90	4.74	Snow							2.79	0.90	2.51	-0.20	1.95	0.50	E	0.98		0.98	0.78
RM45	6/09/85	4.89		4.73	Snow	1.42	1.42	0.10	11	3.31	2.79		0.90	2.51	-0.20	1.94	0.50	E	0.97		0.97	0.77
		Probe likely stopped by ice layers in the snow. Snow depth indicated by stake is used.																				
RM74	8/27/85	0.45			Ice								0.90	0.41	-2.30						-2.10	-2.30
		b′ based on depth of hole from which stake had recently fallen.																			No results	
		STAKE 85-A (installed 6/08/85)											Ice balance continued from Stake 84-A.									
M39	6/08/85			8.74	Snow							6.91	0.90	6.22	-0.20	1.83	0.50	E	0.92		0.92	0.72
RM45	6/09/85	8.85			Snow		1.94				6.91	6.91	0.90	6.22	-0.20	1.94	0.50	E	0.97		0.97	0.77
		Snow depth from Stake 84-A.																				
RM74	8/27/85	4.56	4.57	4.44	Ice								0.90	4.00	-2.42						-2.22	-2.42
	9/30/85	(Hydrologic year ends)												3.15	-3.27				0.00		-3.07	-3.27
	10/13/85	(Minimum balance)												3.04					0.00		-3.18	
RM87	12/03/85	3.61			Snow	0.32	0.32	0.04	21	3.29	3.38		0.90	3.04		0.23	0.31	E	0.07			
		See 1986 measurement year for average *b′ss*.																				
											1986 MEASUREMENT YEAR												
		STAKE 85-A (installed 6/08/85)																				
RM74	8/27/85	4.56	4.57	4.44	Ice								0.90	4.00								
	10/01/85	(Hydrologic year begins)												3.15	0.00				0.00			0.00
	10/13/85	(Minimum balance)												3.04	-0.11				0.00		0.00	-0.11
RM87	12/03/85	3.61			Snow	0.32	0.32	0.04	21	3.29	3.38		0.90	3.04	-0.11	0.23	0.31	E	0.07		0.07	-0.04
M6	2/17/86		6.83	6.08	Snow							3.38	0.90	3.04	-0.11	2.70	0.40	E	1.08		1.08	0.97
M30	6/14/86	4.35	4.36	4.29	Snow	0.79	0.79	0.05	17	3.50	3.38		0.90	3.04	-0.11	0.91	0.46	E	0.42		0.42	0.31
T51	8/20/86	Stake found melted out.																			No results	
		STAKE 86-A (installed 6/14/86)											Ice balance continued from Stake 85-A.									
M30	6/14/86	8.69	Stake vertical		Snow	0.79	0.79	0.05	17	7.90	7.90		0.90	7.11	-0.11	0.79	0.46	E	0.36		0.36	0.25
T51	8/20/86	4.53	4.50	4.49	Ice								0.90	4.04	-3.18						-3.07	-3.18
	9/30/86	(Hydrologic year ends)												2.98	-4.24				0.00		-4.13	-4.24
	11/02/86	(Minimum balance)												2.66	-4.56				0.00		-4.45	
T30	6/14/87				Snow	1.72	1.72	0.04	15	2.96	2.96		0.90	2.66		1.72	0.49	E	0.84			
		Stake bent badly.									Snow dug away from stake for direct observation of *b′ss*.											

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE									
		<--Stake Reading-->				<--Snow Depth-->					Summer Surface		<--Old Firn and Ice-->			<--Snow and New Firn-->					Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b′*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	*bn*	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1987 MEASUREMENT YEAR																						
		STAKE 86-A (installed 6/14/86)																				
	10/01/86	(Hydrologic year begins)												2.98	0.00				0.00			0.00
	11/02/86	(Minimum balance)												2.66	-0.32				0.00		0.00	-0.32
RM2	2/10/87				Snow		2.72	2.72	0.10	15		2.96	0.90	2.66	-0.32	2.72	0.40	E	1.09		1.09	0.77
		Stake buried by snow																				
T30	6/14/87	Stake bent badly.			Snow		1.72	1.72	0.04	15	2.96	2.96	0.90	2.66	-0.32	1.72	0.49	E	0.84		0.84	0.52
		2.96			Ice						Snow dug away from stake for direct observation of *b′* at the glacier ice surface.											
M45	10/01/87	Stake fallen over; bow from 2.5 to 4.0 m.																				
		STAKE 87-A (installed 6/15/87)											Ice balance continued from Stake 86-A.									
M33,T31	6/15/87	6.60			Snow		1.72	1.72	0.04	15	4.88	4.88	0.90	4.39	-0.32	1.72	0.49	E	0.84		0.84	0.52
	9/30/87	(Hydrologic year ends)																	0.00		-3.23	-3.55
M45	10/01/87	1.35	1.51	1.29	Ice								0.90	1.16	-3.55						-3.23	
	10/10/87	(Minimum balance)												1.09	-3.62				0.00		-3.30	
M6	3/18/88	Stake buried.			Snow		4.11	4.11	0.16	6						4.11	0.43	E	1.77			
		Stake not found by digging.																				

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Stake Reading: Tape *b'*	Survey *b**	Survey *b***	Stratum	Snow Depth: Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice: Density ρ	Stake *b'(i)*	Ice *b(i)*	Snow and New Firn: Depth *d*	Density ρ		Snow *b(s)*	NFirn *b(f)*	Yearly Results: Net *bn*	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
													1988 MEASUREMENT YEAR									
		STAKE 87-A2 (installed 10/01/87)																				
	10/01/87	(Hydrologic year begins)													0.00				0.00			0.00
	10/1-10/87	(Minimum balance)												5.22	0.00				0.00		0.00	0.00
M46,RM21	10/01/87	6.07	6.06	6.12	Ice	(readings at the stake)								5.22								
		5.77		5.83	Ice	(area average readings)					5.83	5.80	0.90	5.22	0.00				0.00		0.00	0.00
M6	3/18/88	Stake buried.			Snow		4.11	4.11	0.16	6		5.80	0.90	5.22	0.00	4.11	0.43	E	1.77		1.77	1.77
M8	3/19/88	Stake buried.			Snow			4.11	Assumed depth.			5.80	0.90	5.22	0.00	4.11	0.43	m	1.77		1.77	1.77
						Dug up a wide area without finding the stake.										Pit to depth of 1.60 m; density 0.345 kg/L.						
RM7	6/09/88	8.51		8.40	Snow	2.64		2.64		1	5.76	5.80	0.90	5.22	0.00	2.60	0.587	M	1.53		1.53	1.53
M38	9/18/88		3.15	3.17	Ice								0.90	2.85	-2.37						-2.37	-2.37
RM19	9/20/88	3.15			Ice								0.90	2.84	-2.38						-2.38	-2.38
		Stake very loose and leaning in water-filled hole; may be unreliable.																				
		Leaning stake propped up. Stake found bowed from 6.2 to 7.5 m.																				
	9/30/88	(Hydrologic year ends)												2.74	-2.48				0.00		-2.48	-2.48
	10/13/88	(Minimum balance)												2.64					0.00		-2.58	
T11	2/16/89	Site not measured.																				
T58	6/15/89	1.97			Ice								0.90	1.77								
		STAKE 88-A (installed 3/18/88 by pushing it into the snow to the ice surface)																				
M7	3/18/88				Snow		4.18	4.18		1	0.00	0.00				4.18	0.43	E	1.80		1.80	
M8	3/19/88	4.85	Stake vertical		Snow		4.09	4.09	0.19	5		0.00				4.85	0.43	m	2.09		2.09	
						Probe to a false summer surface.										Pit to depth of 1.60 m; density 0.345 kg/L.						
RM7	6/09/88	2.61	2.61	2.64	Snow	2.64		2.64		1	0.00	0.00				2.64	0.587	M	1.55		1.55	
													1989 MEASUREMENT YEAR									
		STAKE 87-A2 (installed 10/01/87)																				
RM19	9/20/88	3.15		3.17	Ice								0.90	2.84								
		Leaning stake propped up.																				
	10/01/88	(Hydrologic year begins)												2.74	0.00				0.00			0.00
	10/13/88	(Minimum balance)												2.64	-0.10				0.00		0.00	-0.10
T11	2/16/89	Site not measured.																				
T58	6/15/89	2.00		1.97	Ice								0.90	1.77	-0.97						-0.87	-0.97
		Stake reset in same hole. 0.10 m(w) icemelt from 6/15 to 6/17 estimated using weather data.																				
T63	6/17/89	6.10			Ice								0.90	5.49	-1.07						-0.97	-1.07
	9/30/89	(Hydrologic year ends)																	0.00		----	----
T157	10/03/89	Surveyed stake base at ice surface; stake melted out.													<-6.74				0.03		<6.64	<-6.74
T158	10/04/89							0.10								0.10	0.30	E	0.03		----	
																Visual estimate of snow cover over entire glacier.						
	10/08/89	(Minimum balance)																	0.00		----	

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results Net *bn*	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1990 MEASUREMENT YEAR																						
		STAKE 89-A (installed 10/03/89)																				
	10/01/89	(Hydrologic year begins)												7.10	0.00							0.00
T157	10/03/89	7.90	7.97	7.85	Ice								0.90	7.07	-0.03							-0.03
T158	10/04/89							0.10		.				7.07	-0.03	0.10	0.30	E	0.03		0.03	0.00
		Visual observation of snow cover over entire glacier.																				
	10/08/89	(Minimum balance)													-0.16				0.00		0.00	-0.16
T60	10/08/89	7.85			Ice						7.85	7.71	0.90	6.94	-0.16							-0.16
T53	2/14/90	9.50	9.46	9.36	Snow							7.71	0.90	6.94	-0.16	1.65	0.36	E	0.59		0.59	0.43
T63	3/17/90	9.60			Snow	1.95	1.95	0.02	4		7.65	7.71	0.90	6.94	-0.16	1.89	0.37	E	0.70		0.70	0.54
M23	6/02/90	7.87	7.89	7.76	Ice			0.02			7.74	7.71	0.90	6.94	-0.16	0.02	0.90	E	0.02		0.02	-0.14
		Snow with superimposed ice covers 40% of surface.																				
M34	9/07/90		2.04	1.35	Ice								0.90	1.22	-5.88						5.72	-5.88
M35	9/10/90	2.00		1.31	Ice								0.90	1.18	-5.92						-5.76	-5.92
		STAKE 90-A (installed 9/10/90)											Ice balance continued from Stake 89-A.									
M35	9/10/90	8.10		8.10	Ice								0.90	7.29	-5.92						-5.76	-5.92
	9/30/90	(Hydrologic year ends)												6.95	-6.26				0.00		-6.10	-6.26
	10/12/90	(Minimum balance)												6.87					0.00		-6.18	
M5	1/07/91		7.78	7.75	Snow	0.12	0.12	0.03	10		7.63	7.63	0.90	6.87		0.12	0.35	E	0.04			
1991 MEASUREMENT YEAR																						
		STAKE 90-A (installed 9/10/90)																				
M35	9/10/90	8.10		8.10	Ice								0.90	7.29								
	10/01/90	(Hydrologic year begins)											0.90	6.95	0.00				0.00			0.00
	10/12/90	(Minimum balance)										7.63	0.90	6.87	-0.08				0.00		0.00	-0.08
M5	1/07/91	7.75	7.78	7.75	Snow	0.12	0.12	0.03	10		7.63	7.63	0.90	6.87	-0.08	0.12	0.35	E	0.04		0.04	-0.04
M16	5/13/91		9.38	9.41	Snow							7.63	0.90	6.87	-0.08	1.78	0.45	E	0.80		0.80	0.72
M32	9/12/91		3.49	3.48	Ice								0.90	3.13	-3.82						-3.74	-3.82
M39	9/18/91	3.15		3.15	Ice								0.90	2.84	-4.11						-4.03	-4.11
M4	1/23/92	Stake buried.																			----	----
		STAKE 91-A (installed 9/18/91)											Ice balance continued from Stake 90-A.									
M39	9/18/91	8.90		8.90	Ice								0.90	8.01	-4.11						-4.03	-4.11
	9/30/91	(Hydrologic year ends)												8.00	-4.12				0.00		-4.04	-4.12
	10/1-8/91	(Minimum balance)												8.00					0.00		-4.04	
M3	1/23/92		10.66	10.67	Snow							8.89	0.90	8.00		1.78	0.39	E	0.69			
M7	1/27/92		Assumed	10.60	Snow			1.80			8.80	8.89				1.80	0.39	E	0.70			
		Snow depth measured at nearby glacier surface marker. See 1992 measurement year for average *b'ss*.																				

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS												SURFACE MASS BALANCE										
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field Notes	Date	Tape b'	Survey b^*	b^{**}	*Stratum*	Pit/Core d	Probe d	Average d	*s.e.*	*n*	Obsvd. $b'ss$	Average $b'ss$	Density ρ	Stake $b'(i)$	Ice $b(i)$	Depth d	Density ρ		Snow $b(s)$	NFirn $b(f)$	Net bn	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1992 MEASUREMENT YEAR																						
		STAKE 91-A (installed 9/18/91)																				
M39	9/18/91	8.90		8.90	Ice								0.90	8.01								
	10/01/91	(Hydrologic year begins)												8.00	0.00							0.00
	10/1-8/91	(Minimum balance)										8.89	0.90	8.00	0.00				0.00		0.00	0.00
M3	1/23/92		10.66	10.67	Snow							8.89	0.90	8.00	0.00	1.78	0.39	E	0.67		0.67	0.67
M7	1/27/92		Assumed	10.60	Snow			1.80			8.80	8.89				1.71	0.39	E	0.67			
								Snow depth measured at nearby ice surface marker.														
M12	5/13/92		10.77	10.78	Snow							8.89	0.90	8.00	0.00	1.89	0.50	E	0.95		0.95	0.95
M14	5/16/92	10.73			Snow		1.82	1.82	0.02	6	8.91	8.89	0.90	8.00	0.00	1.84	0.50	E	0.92		0.92	0.92
M61	9/06/92	5.74	5.64	5.71	Ice								0.90	5.14	-2.86						-2.86	-2.86
														Icemelt after 9/06/92 estimated from weather data.								
	9/30/92	(Hydrologic year ends)												4.86	-3.14				0.00		-3.14	-3.14
	10/08/92	(Minimum balance)										5.29	0.90	4.76	-3.24				0.00		-3.24	
														Summer surface height calculated from minimum mass balance.								
M5	2/09/93		6.91	6.89	Snow							5.29	0.90	4.76		1.60	0.38	E	0.61			

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Stake Reading: Tape *b'*	Stake Reading: Survey *b**	Stake Reading: Survey *b***	Stratum	Snow Depth: Pit/Core *d*	Snow Depth: Probe *d*	Snow Depth: Average *d*	Snow Depth: *s.e.*	Snow Depth: *n*	Summer Surface: Obsvd. *b'ss*	Summer Surface: Average *b'ss*	Old Firn and Ice: Density *ρ*	Old Firn and Ice: Stake *b'(i)*	Old Firn and Ice: Ice *b(i)*	Snow and New Firn: Depth *d*	Snow and New Firn: Density *ρ*		Surface Mass Balance: Snow *b(s)*	Surface Mass Balance: NFirn *b(f)*	Yearly Results: Net *bn*	Yearly Results: Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1993 MEASUREMENT YEAR																						
		STAKE 91-A (installed 9/18/91)																				
M61	9/06/92	5.74	5.64	5.61	Ice																	
				5.71	Best *b'*; lean correction and measured average ice level at stake.								0.90	5.14								
	10/01/92	(Hydrologic year begins)												4.86	0.00				0.00			0.00
	10/08/92	(Minimum balance)										5.29	0.90	4.76	-0.10				0.00		0.00	-0.10
												Summer surface height calculated from minimum mass balance.										
M5	2/09/93		6.91	6.89	Snow							5.29	0.90	4.76	-0.10	1.60	0.38	E	0.61		0.61	0.51
M17	5/16/93		7.17	7.18	Snow							5.29	0.90	4.76	-0.10	1.89	0.50	E	0.95		0.95	0.85
M32	9/10/93	Stake found melted out.																			----	----
		STAKE 92-A (installed 9/07/92)																				
M63	9/07/92	8.00	7.99	7.95	Ice								0.90	7.19								
	10/01/92	(Hydrologic year begins)												6.91	0.00				0.00			0.00
	10/08/92	(Minimum balance)										7.57	0.90	6.81	-0.10				0.00		0.00	-0.10
												Summer surface height calculated from minimum mass balance.										
	2/09/93	Stake survey incomplete for *b** and *b***.																				
M17	5/16/93		9.29	9.29	Snow							7.57	0.90	6.81	-0.10	1.72	0.50	E	0.86		0.86	0.76
M32	9/10/93		3.72	3.71	Ice								0.90	3.34	-3.57						-3.47	-3.57
M34	9/11/93	3.70			Ice								0.90	3.33	-3.58						-3.48	-3.58
M37	9/13/93	3.40			Ice								0.90	3.06	-3.85						-3.75	-3.85
	9/30/93	(Hydrologic year ends)												2.78	-4.13				0.00		-4.03	-4.13
	10/16/93	(Minimum balance)										2.73	0.90	2.46	-4.45				0.00		-4.35	
M4	2/05/94		4.70	4.68	Snow							2.73	0.90	2.46		1.95	0.38	E	0.74			
M14	5/14/94		4.61	4.57	Snow							2.73	0.90	2.46		1.84	0.44	E	0.81			
M16	5/16/94	4.55			Snow	1.82		1.82	0.03	5	2.73	2.73	0.90	2.46		1.82	0.44	E	0.80			
1994 MEASUREMENT YEAR																						
		STAKE 93-A (installed 9/13/93; no connector at 6 m so top part will fall freely next summer)																				
M37	9/13/93	9.13	9.13	9.08	Ice								0.90	8.17								
	10/01/93	(Hydrologic year begins)												8.11	0.00				0.00			0.00
	10/16/93	(Minimum balance)												7.99	-0.12				0.00		0.00	-0.12
M4	2/05/94		10.65	10.59	Snow							8.88	0.90	7.99	-0.12	1.71	0.36	E	0.62		0.62	0.50
M14	5/14/94		10.70	10.64	Snow							8.88	0.90	7.99	-0.12	1.76	0.45	E	0.79		0.79	0.67
M16	5/16/94	10.70			Snow	1.82		1.82	0.03	5	8.88	8.88	0.90	7.99	-0.12	1.82	0.44	E	0.80		0.80	0.68
M25	9/07/94	3.40			Ice								0.90	3.06	-5.05						-4.93	-5.05
M27	9/09/94		3.30	3.21	Ice								0.90	2.89	-5.22						-5.10	-5.22
	9/30/94	(Hydrologic year ends)												2.74	-5.37						-5.25	-5.37
	10/16/95	(Minimum balance)												2.66	-5.45						-5.33	
M3	1/31/95		4.96	4.81	Snow			1.86			2.95	2.95	0.90	2.66		1.86	0.36	E	0.67			
								Snow depth measured at Stake 94-A.														

Table 2. Mass balance data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE									
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn					Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average			Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		b'	b^*	b^{**}	*Stratum*	d	d	d	*s.e.*	n	$b'ss$	$b'ss$	ρ	$b'(i)$	$b(i)$	d	ρ		$b(s)$	$b(f)$	bn	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1995 MEASUREMENT YEAR																						
STAKE 93-A (installed 9/13/93; no connector at 6 m so top part will fall freely next summer)																						
M27	9/09/94		3.30	3.21	Ice								0.90	2.89								
	9/30/94	(Hydrologic year begins)												2.74	0.00				0.00			0.00
	10/16/95	(Minimum balance)												2.58	-0.16				0.00		0.00	-0.16
M3	1/31/95		4.96	4.81	Snow							2.87	0.90	2.58	-0.16	1.94	0.36	E	0.70		0.70	0.54
	5/11/95	Stake not observed			Snow		1.94	1.94	0.05	5		2.87	0.90	2.58	-0.16	1.94	0.45	E	0.87		0.87	0.71
M13	5/14/95			4.74	Snow			1.87			2.87	2.87	0.90	2.58	-0.16	1.87	0.45	E	0.84		0.84	0.68
		Snowmelt from 5/14 to 5/15 estimated from weather data.																				
M31	9/15/95	0.71			Ice	Stake may have melted into the ice.							0.90	0.64	-2.10						-1.94	-2.10
STAKE 94-A (installed 9/07/94; no connector at 6 m)																						
M25	9/07/94	10.05			Ice								0.90	9.05								
M27	9/09/94		10.06	9.91	Ice								0.90	8.92								
	10/01/94	(Hydrologic year begins)												8.60	0.00				0.00			0.00
	10/16/95	(Minimum balance)												8.42	-0.18				0.00		0.00	-0.18
M3	1/31/95		11.35	11.21	Snow							9.35	0.90	8.42	-0.18	1.86	0.36	E	0.67		0.67	0.49
M9	5/11/95	11.43		11.29	Snow		1.94	1.94	0.05	5	9.35	9.35	0.90	8.42	-0.18	1.94	0.50	E	0.97		0.97	0.79
		Stake not surveyed; lean correction measured on 5/14/95 applied to $b'ss$.														Snow is wet.						
M12	5/14/95		11.36	11.23	Snow							9.35	0.90	8.42	-0.18	1.88	0.50	E	0.94		0.94	0.76
M26	9/14/95	5.09	5.12	5.16	Ice								0.90	4.64	-3.96						-3.78	-3.96
	9/30/95	(Hydrologic year ends)													-4.71				0.00		-4.53	-4.71
	10/09/95	(Minimum balance)												3.75	-4.85				0.00		-4.67	
T2, BK3	1/12/96	5.10	5.06	5.12	Snow	0.90	0.96	0.95	0.03	18	4.17	4.17	0.90	3.75	-4.85	0.95	0.354	M	0.34			
		Snow core, 4 measurements using the McCall tube; 14 additional depth measurements by probing.																				

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska.

[Field Notes, locator for observation notebook entries; abbreviation methods are explained in the Mass balance data section. Stake Reading, *b′*, average height of the surface above a stake base within 3- to 5-m radius, measured by pocket tape; *b**, average surface height on a stake measured by surveying; *b***, average surface height on a leaning stake calculated (beginning in 1979) as the vertical distance between the stake base and the sloping glacier surface above it, and is the most accurate stake reading. *Stratum*, mass balance stratigraphic unit; Sice, superimposed ice; OFirn, old firn; SFirn, superimposed ice in old firn; NFirn, new firn. Snow Depth, *d*, measured vertically in pits and core holes and by probing. Average depth, *d;* standard error, *s.e.;* and number of observations, *n*, calculated from the pit, core, and probe data. Measured summer surface height between stratigraphic units, Obsvd. *b'ss*, is each stake reading minus the average snow or new firn depth at a pit or a core hole measured at the same time. Average summer surface height at the stake, Average *b'ss*, is the average of the measured summer surfaces each season weighted by the number of measurements each observation. Old Firn and Ice Density, ρ, is estimated unless noted as measured. The water equivalent depth of old firn and ice above the stake base, *b′(i),* is used to calculate the old firn and ice loss, $b_a(i)$, since the beginning of the hydrologic year. Snow and New Firn Depth, *d,* listed under Surface Mass Balance, is the difference between the most accurate stake reading, *b′, b*,* or *b**,* and the average summer surface height at the stake, Average *b'ss.* Snow and New Firn Density, ρ, is measured, M; partially measured, m; or estimated, E; see Mass balance data section for methods. Surface Mass Balance Yearly Results, *b(i),* old firn and ice balance after October 1; *b(s),* snow balance; *b(f),* either net or annual new firn balance; b_n, yearly net balance; and b_a, annual balance, are derived from the measurements and explained in the End-of-year estimates section and by Mayo and others, 1972. Measurement units are m/d/y, month/day/year; m, meters; kg/L, kilograms per liter; m(w), meters water equivalent; °C, degrees Celsius; km, kilometers; g, grams; m^2, square meters; mm, millimeters; ----, no data available]

<----------OBSERVATIONS---------->		<---------Stake Reading--------->				<----------Snow Depth---------->					Summer Surface		<----Old Firn and Ice---->			<--------Snow and New Firn-------->				Yearly Results	
Field Notes	Date	Tape *b′*	Survey *b**	*b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Obsvd. *b'ss*	Average *b'ss*	Density ρ	Stake *b′(i)*	Ice *b(i)*	Depth *d*	Density ρ		Snow *b(s)*	NFirn *b(f)*	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1966 MEASUREMENT YEAR																						
M48B	4/23/66				Snow		2.30	2.30		1						2.30	0.44	E	1.01		1.01	----
		This measurement is located 1 km down-glacier from site B.																				
PP715-A		(Minimum balance)	Estimate at site from mass balance map (Meier and others, 1971).																0.00		-1.00	----
M165A	10/24/66				Snow		0.80	0.80		1						0.80	0.32	E	0.26			
1967 MEASUREMENT YEAR																						
		(Minimum balance)	Date unknown; no weather data at the glacier.																0.00			
M165A	10/24/66				Snow		0.80	0.80		1						0.80	0.32	E	0.26		0.26	----
Data Form	4/01/67				Snow	0.97		0.97		1						0.97	0.362	M	0.35		0.35	----
M22E	4/04/67				Snow		2.10	2.10		1						2.10	0.42	E	0.88		0.88	----
		STAKE 67-16 (installed 6/02/67)																				
M88D	6/02/67	2.70			Snow		1.20	1.20		1	1.50		0.90	1.35		1.20	0.49	E	0.59		0.59	----
M139C	9/20/67	Stake found melted out; temporarily reinstalled in a narrow crevasse.																			<-1.35	----
		4.00			Ice								0.90	3.60								
		Stake not seen again until Oct. 16, 1971.																				
PP715-B	9/24/67	(Minimum balance)	Estimate from mass balance map (Tangborn and others, 1977).																		-2.00	----

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----		<---Stake Reading--->				<---Snow Depth--->						<-----SURFACE MASS BALANCE-----									
											Summer Surface		<---Old Firn and Ice--->			<---Snow and New Firn--->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average			Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		b'	b^*	b^{**}	*Stratum*	d	d	d	*s.e.*	n	$b'ss$	$b'ss$	ρ	$b'(i)$	$b(i)$	d	ρ		$b(s)$	$b(f)$	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1968 MEASUREMENT YEAR																						
		STAKE 68-21A (installed 1/26/68, inserted in snow to ice)																				
	9/24/67	(Minimum balance)												-0.10					0.00		0.00	
	10/01/67	(Hydrologic year begins)												-0.10	0.00				0.13		0.13	0.00
M2A	1/26/68	1.92			Snow	2.02	1.96	1.97	0.03	3	-0.05	-0.11	0.90	-0.10	0.00	2.03	0.418	M	0.85		0.85	0.72
M4A	1/29/68	1.87			Snow							-0.11	0.90	-0.10	0.00	1.98	0.42	E	0.83		0.83	0.70
		(Raised ski tracks indicate recent snow loss caused by erosion by wind)																				
M5B	1/30/68	1.86			Snow							-0.11	0.90	-0.10	0.00	1.97	0.42	E	0.83		0.83	0.70
M6D	3/29/68	3.03			Snow							-0.11	0.90	-0.10	0.00	3.14	0.41	E	1.29		1.29	1.16
	4/04/68	(Snow balance measured using stratigraphy in snow pit, 4/08/68)																	1.31		1.31	1.18
M19E	4/08/68	3.25			Snow	3.64	3.25	3.45	0.14	2	-0.20	-0.11	0.90	-0.10	0.00	3.36	0.413	M	1.39		1.39	1.26
M62C	6/05/68	2.59			Snow							-0.11	0.90	-0.10	0.00	2.70	0.60	E	1.62		1.62	1.49
M63C	6/06/68	2.58			Snow							-0.11	0.90	-0.10	0.00	2.69	0.60	m	1.61		1.61	1.48
						Snow density measured to top of slush at depth of 2.32 m; density, 0.54 kg/L. Slush density estimated, 0.90 kg/L.																
M81D	7/20/68	0.87			Snow							-0.11	0.90	-0.10	0.00	0.98	0.78	m	0.76		0.76	0.63
		Stake abandoned.				Snow density measured to top of slush at depth of 0.45 m; density, 0.57 kg/L. Slush density estimated, 0.90 kg/L.																
		STAKE 68-21 (installed 1/26/68 in snow pit)											Ice balance continued from stake 68-21A.									
M2A	1/26/68	10.72			Snow	2.02	1.96	1.97	0.03	3	8.75	8.75	0.90	7.88	0.00	1.97	0.418	M	0.82		3.21	3.08
M88F	8/21/68	7.70			Ice								0.90	6.93	-0.95						-0.95	-1.08
	9/24/68	(Minimum balance)												6.44	-1.44				0.00		-1.44	-1.57
	9/30/68	(Hydrologic year ends)												6.44	-1.44				0.09			-1.48
M107B	10/05/68	7.65			Snow							7.15	0.90	6.44	-1.44	0.50	0.28	E	0.14			
						See 1969 measurement year for average $b'ss$.																

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1969 MEASUREMENT YEAR																						
		STAKE 68-21 (installed 1/26/68 in snow pit at site B)																				
M88F	8/21/68	7.70			Ice									6.44								
	9/24/68	(Minimum balance)																	0.00		0.00	
	10/01/68	(Hydrologic year begins)												6.44	0.00				0.09		0.09	0.00
M107B	10/05/68	7.65			Snow							7.15	0.90	6.44	0.00	0.50	0.28	E	0.14		0.14	0.05
M109E	10/10/68	7.61			Snow	0.46		0.46		1	7.15	7.15	0.90	6.44	0.00	0.46	0.294	M	0.14		0.14	0.05
M80A	7/31/69	6.87			Ice	Transient snowline 15 to 20 m from stake.							0.90	6.18	-0.26						-0.26	-0.35
M99D	9/12/69	6.03			Snow		0.03	0.03		1	6.00	6.00	0.90	5.40	-1.04	0.03	0.30	E	0.01		-1.03	-1.12
M105B	9/17/69	5.97			Ice								0.90	5.37	-1.07						-1.07	-1.16
					Surface half covered with fresh snow.																	
	9/26/69	(Minimum balance)			Final ice melt measured at Stake 69-C.										-1.12				0.00		-1.12	-1.21
	9/30/69	(Hydrologic year ends)													-1.12				0.12			-1.09
		STAKE 69-21A (installed 10/06/68; no wood plug in base)																				
	9/24/68	(Minimum balance)																	0.00		0.00	
	10/01/68	(Hydrologic year begins)												0.96	0.00				0.09		0.09	0.00
M108C	10/06/68	1.52			Snow		0.52	0.52		1	1.00	1.07	0.90	0.96	0.00	0.45	0.25	E	0.11		0.11	0.02
M109E	10/10/68	1.45			Snow	0.46		0.46		1	0.99	1.07	0.90	0.96	0.00	0.38	0.294	M	0.11		0.11	0.02
M3C	1/27/69	2.77			Snow	1.64		1.64		1	1.13	1.07	0.90	0.96	0.00	1.70	0.392	M	0.67		0.67	0.58
M8F	4/12/69	5.05			Snow	4.05	3.93	3.96	0.04	4	1.09	1.07	0.90	0.96	0.00	3.98	0.356	M	1.42		1.42	1.32
M23C	4/18/69	5.11			Snow							1.07	0.90	0.96	0.00	4.04	0.36	E	1.45		1.45	1.35
M65B	6/04/69	4.40			Snow							1.07	0.90	0.96	0.00	3.33	0.59	E	1.96		1.96	1.86
M66A	6/05/69	4.30			Snow							1.07	0.90	0.96	0.00	3.23	0.64	m	2.07		2.07	1.98
					Pit to water table at depth of 2.72 m; density, 0.56 kg/L.																	
					Slush and ice below the depth of 2.72 m cannot be sampled; assumed density of the slush is 0.90 kg/L.																	
					Ice layer at depth of 2.87 m is too thick to penetrate with probe.																	
		STAKE 68-C (installed 6/06/68 200 m east of Site B)													Ice balance continued from Stake 69-21A.							
M110A	10/10/68	2.20			Snow		0.50	0.50		1	1.70	1.71	0.90	1.54	0.00	0.49	0.29	E	0.14		0.14	0.05
M79D	7/31/69	1.72			Ice						1.72	1.71	0.90	1.54	0.00						0.00	-0.09
					Stake located at the transient snowline.																	
M99G	9/13/69	1.00			Snow		0.08	0.08	0.01	5	0.92	0.92	0.90	0.83	-0.71	0.08	0.32	E	0.03		-0.68	-0.77
	9/26/69	(Minimum balance)													-0.76				0.00		-0.76	-0.85
	9/30/69	(Hydrologic year ends)													-0.76				0.12			-0.73
M110A	11/19/69	2.85			Snow		1.98	1.98	0.03	4	0.87	0.87	0.90	0.78	-0.76	1.98	0.40	E	0.79			
					Snow density measured at Stake 70-21A; see 1970 measurement year.																	
																					Average of 2 stakes:	-0.94	-0.91

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1970 MEASUREMENT YEAR																						
		STAKE 70-21A (installed 9/17/69; no wood plug in base)																				
M105B	9/17/69	1.00			Ice																	
	9/26/69	(Minimum balance)																	0.00		0.00	
	10/01/69	(Hydrologic year begins)													0.00				0.12		0.12	0.00
M110B	11/19/69	3.35			Snow	1.25	1.25	1.25	0.02	5	2.10	2.11	0.90	1.90	0.00	1.24	0.40	M	0.50		0.50	0.38
		2.08			Ice						2.08											
		Ice surface height, *b'*, measured at the stake.									Stake sank before freezing in.											
M20D	4/11/70	Stake buried.			Snow	6.00	5.90	5.95	0.02	2		2.11	0.90	1.90	0.00	5.95	0.442	M	2.63		2.63	2.51
Z17A	6/09/70	Stake buried.			Snow	4.40		4.40		1		2.11	0.90	1.90	0.00	4.40	0.569	M	2.50		2.50	2.38
		Pit to 1.58-m depth; core to ice at 4.40-m depth.																				
M44A	7/24/70	5.40			Snow	3.02		3.02		1	2.38	2.11	0.90	1.90	0.00	3.29	0.615	M	2.02		2.02	1.90
		Pit to 1.25-m depth;core to dirty ice at 3.02-m depth.																				
	9/19/70	(Minimum balance)																	0.94	0.86	0.86	0.74
																			Difference of 0.08 m is water.			
M72C	9/20/70	3.54			NFirn														0.94	0.86		
M75I	9/27/70	3.54	(Assumed *b'*)		NFirn	1.63		1.63		1	1.91	2.11	0.90	1.90	0.00	1.43	0.66	m	0.94	0.86		
	Weather cold since 9/20; no new snow.					Pit to the water table at depth of 1.32 m; density to depth of 1.20 m, 0.559 kg/L. New firn frozen to depth of 0.80 m.																
		Density of the new firn includes 0.31-m deep slush layer below the water table; density estimated, 0.90 kg/L.																				
		Water content of the new firn is the sum of the water in the unsaturated firn plus the water in the slush layer.																				
		Slush at the base of the snow will become solid ice when it freezes; a false summer surface.																				
	9/30/70	(Hydrologic year ends)													0.00				0.01	0.86		0.75
M4B	1/11/71	5.30			Snow	2.02	1.25			1		3.54				1.76	0.369	M	0.65			
							Probe to ice, a false summer surface.					*b'ss* observed at the stake on 9/20/70.										
		Pit located 100 m up glacier from the stake to avoid the slush layer present at the stake on 9/27/70, and frozen now.																				
		STAKE 71-21A (installed 9/28/70, no label, no wood plug; base on ice surface)																				
	9/26/69	(Minimum balance)																	0.00		0.00	
	10/01/69	(Hydrologic year begins)																	0.12		0.12	0.00
	9/19/70	(Minimum balance)																	0.97	0.88	0.88	0.76
																			Difference of 0.09 m is water.			
M76A	9/28/70	1.47			NFirn		1.47	1.47		1	0.00	0.00				1.47	0.66	E	0.97	0.88	0.88	0.76
	9/30/70	(Hydrologic year ends)																	0.01	0.88		0.89
M83J	10/04/70	1.55			Snow						1.47	1.47				0.08	0.30	E	0.02			
M4B	1/11/71	Stake found blown down.																				
																			Average of 2 stakes:		0.87	0.82

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape b'	Survey b^*	Survey b^{**}	Stratum	Pit/Core d	Probe d	Average d	s.e.	n	Summer Surface Obsvd. $b'ss$	Summer Surface Average $b'ss$	Old Firn and Ice Density ρ	Stake $b'(i)$	Ice $b(i)$	Snow and New Firn Depth d	Density ρ		Snow $b(s)$	NFirn $b(f)$	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1971 MEASUREMENT YEAR																						
		STAKE 70-21A (installed 9/17/69; no wood plug in base)																				
M44A	7/24/70	5.40			Snow	3.02		3.02		1	2.38											
						Pit to 1.25-m depth; core to dirty ice at depth of 3.02 m.																
	9/19/70	(Minimum balance)																	0.00		0.00	
M72C	9/20/70	3.54			OFirn																	
M75I	9/27/70	(3.54)	Assumed b'		OFirn	1.63		1.63		1	1.91	1.91				1.63	0.60	m	0.98			
					Ice							1.91	0.90	1.72								
												SUMMARY NOTE FOR STAKE 70-21A										
												2 layers at the time of minimum balance:										
													Depth	Density	$b'(i)$							
		See Stake 70-21A in the 1970 measurement year, for 1970 firn data.										OFirn	1.63	0.60	0.98							
												Ice	1.91	0.90	1.72							
												Total	3.54		2.70							
	9/30/70	(Hydrologic year begins)												2.70	0.00				0.01		0.01	0.00
M4B	1/11/71	5.30			Snow	2.02	1.25	2.02		1		3.54	2 Layers	2.70	0.00	1.76	0.369	M	0.65	0.65	0.65	0.64
						Probe to ice layer, a false summer surface.						$b'ss$ observed at the stake on 9/20/70 was 3.54 m.										
						Pit located near blown over Stake 71-21A; 1970 summer surface marked by dirt.																
						Pit located 100 m up glacier from the stake to avoid the slush layer present at the stake on 9/27/70.															----	----
M34C	4/27/71	Stake buried			Snow		4.63	4.63	0.07	4		3.54	2 Layers	2.70	0.00	4.63	0.46	E	2.13		2.13	2.12
M35D	4/29/71	Stake buried			Snow	4.79		4.79		1		3.54	2 Layers	2.70	0.00	4.79	0.404	M	1.94		1.94	1.93
M66F	7/10/71	Stake buried			Snow	3.65	3.66	3.66	0.04	6		3.54	2 Layers	2.70	0.00	3.66	0.57	M	2.09		2.09	2.08
M76D	8/13/71	4.50 or 1.50			Snow	1.80	1.58	1.62	0.04	6		3.54	2 Layers	2.70	0.00	1.62	0.60	E	0.97		0.97	0.96
		Stake identity in question.				1970 summer surface observed at depth of 1.80 m in pit dug on 7/10/71.										Stake reading not used to calculate snow depth.						
	----	(Minimum balance)				Date unknown; no weather data at the glacier.								2.51	-0.19				0.00		-0.19	---
	9/30/70	(Hydrologic year ends)				Final balance conditions for the hydrologic year not known; no weather data at the glacier.													---		---	---
M101C	10/14/71	4.15			Snow							3.27	2 Layers	2.51	-0.19	0.88	0.30	E	0.26			
M101E	10/16/71	4.12			Snow	0.83	0.85	0.85	0.01	11	3.27	3.27				0.85	0.305	M	0.26			

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Tape b'	Survey b^*	Survey b^{**}	Stratum	Pit/Core d	Probe d	Average d	$s.e.$	n	Summer Surface Obsvd. $b'ss$	Summer Surface Average $b'ss$	Old Firn and Ice Density ρ	Old Firn and Ice Stake $b'(i)$	Old Firn and Ice Ice $b(i)$	Snow and New Firn Depth d	Snow and New Firn Density ρ		Yearly Results Snow $b(s)$	Yearly Results NFirn $b(f)$	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1972 MEASUREMENT YEAR																						
STAKE 70-21A (installed 9/17/69; 69-21A label; no wood plug)																						
	----	(Minimum balance)			Date unknown; no weather data at the glacier.							3.27		2.51					0.00		0.00	
	10/01/71	(Hydrologic year begins)			Initial balance conditions not known; no weather data at the glacier.										---				---		---	---
M101C	10/14/71	4.15			Snow							3.27	2 Layers	2.51	---	0.88	0.30	E	0.26		0.26	---
M101E	10/16/71	4.12			Snow	0.83	0.85	0.85	0.01	11	3.27	3.27	2 Layers	2.51	---	0.85	0.305	M	0.26		0.26	---
M108B	10/21/71	4.27			Snow							3.27	2 Layers	2.51	---	1.00	0.31	E	0.31		0.31	---
M3B	1/13/72	5.12			Snow	1.25		1.25		1	3.87	3.27	2 Layers	2.51	---	1.85	0.35	M	0.65		0.65	---
					Pit 50 m from stake; not used to calculate summer surface height at the stake.																	
M10	4/10/72	5.51			Snow	1.68	1.95	1.88	0.07	4	3.63	3.27	2 Layers	2.51	---	2.24	0.354	M	0.79		0.79	---
					Pit to dirty iced-firn.																	
M36G	6/21/72	5.18			Snow	1.60		1.60		1	3.58	3.27	2 Layers	2.51	---	1.91	0.502	M	0.96		0.96	---
M42D	7/12/72	4.15			Snow	0.77		0.77		1	3.38	3.27	2 Layers	2.51	---	0.88	0.52	M	0.46		0.46	---
M60C	8/18/72	2.03			Ice							2.03	0.90	1.83	---						-0.68	
M68H	10/03/72	2.46			Snow		0.03	0.03		1	2.43	2.43	0.90	2.19		0.03	0.30	E	0.01			
	Stake began sinking during summer, so no valid old firn and ice mass balance data after 8/18/72.																					
		STAKE 68-21 (installed 1/26/68)																				
																			Net balance, b_n, continued from Stake 70-21A.			
M60C	8/18/72	5.44			Ice								0.90	4.90	---						-0.68	---
	9/22/72	(Minimum balance)												4.24	---				0.00		-1.34	---
	9/30/72	(Hydrologic year ends)												4.24	---				0.03			---
M68H	10/03/72	4.71			Ice								0.90	4.24	---							
					Ice at the stake; thin snow in the area.																	
		Stake 72-21A (installed 1/13/72; stake base on board placed on iced-firn at the 1971 summer surface)																				
M3B	1/13/72	1.25			Snow	1.25		1.25		1	0.00	-0.15			---	1.40	0.35	M	0.49		0.49	---
M10L	4/10/72	1.82			Snow	1.68	1.95	1.88	0.07	4	-0.06	-0.15			---	1.97	0.35	E	0.69		0.69	---
M36G	6/21/72	1.36			Snow	1.60		1.60		1	-0.24	-0.15			---	1.51	0.502	M	0.76		0.76	---
M42D	7/12/72	0.34			Snow	0.77		0.77		1	-0.43	-0.15			---	0.49	0.52	M	0.25		0.25	---
M68J	10/03/72	Stake not found.																				

SUMMARY NOTE FOR STAKE 70-21A:
2 layers at the time of minimum balance

	Depth	Density	$b'(i)$
OFirn	1.36	0.58	0.79
Ice	1.91	0.90	1.72
Total	3.27		2.51

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----												<-----SURFACE MASS BALANCE-----									
		<---Stake Reading--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice--->			<---Snow and New Firn--->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1973 MEASUREMENT YEAR																						
		STAKE 68-21 (installed 1/26/68)																				
M60C	8/18/72	5.44			Ice																	
	9/22/72	(Minimum balance)												4.24					0.00		0.00	
	10/01/72	(Hydrologic year begins)												4.24	0.00				0.01		0.01	0.00
M68H	10/03/72	4.71			Snow		0.01			1	4.71	4.71	0.90	4.24	0.00	0.01	0.30	E	0.003		0.00	-0.01
M1A	1/04/73	Stake buried.			Snow	1.25	1.65	1.61	0.03	11		4.71	0.90	4.24	0.00	1.61	0.338	M	0.54		0.54	0.53
M17A	4/16/73	Stake buried.			Snow	3.30		3.30		1		4.71	0.90	4.24	0.00	3.30	0.371	M	1.22		1.22	1.21
M29D	6/01/73	Stake buried.			Snow	3.19		3.19		1		4.71	0.90	4.24	0.00	3.19	0.445	M	1.42		1.42	1.41
T20A	7/07/73	Stake buried.			Snow																	
M52D	8/24/73	4.71			Ice at SIce edge.						4.71	4.71	0.90	4.24	0.00						0.00	-0.01
	9/20/73	(Minimum balance)												4.17	-0.07						-0.07	-0.08
	9/30/73	(Hydrologic year ends)												4.17	-0.07				0.04			-0.04
M58A	10/12/73				Snow	0.38		0.38		1				4.17	-0.07	0.38	0.324	M	0.12			
M60C	10/16/73	4.97			Snow		0.34	0.34	0.01	8	4.63	4.63	0.90	4.17	-0.07	0.34	0.32	E	0.11			
		Stake abandoned																				
		STAKE 73-21 (installed 4/17/73 from reused stakes; no 0- to 3-m section; 3- to 6-m labelled "72-1"; 6- to 9-m section has no label)																				
	9/22/72	(Minimum balance)																	0.00		0.00	
	10/01/72	(Hydrologic year begins)													0.00				0.01		0.01	0.00
															Ice balance continued from Stake 68-21.							
M19A	4/17/73	8.90			Snow		3.23	3.23	0.04	7	5.67	5.67	0.90	5.10	0.00	3.23	0.43	E	1.39		1.39	1.38
M29D	6/01/73	Stake buried			Snow	3.19		3.19		1		5.67	0.90	5.10	0.00	3.19	0.445	M	1.42		1.42	1.41
T19A	7/06/73	7.70			Snow							5.67	0.90	5.10	0.00	2.03	0.60	E	1.22		1.22	1.21
T20A	7/07/73	7.60			Snow							5.67	0.90	5.10	0.00	1.93	0.60	m	1.16		1.16	1.15
		Assumed *b'*.				Density measured to top of transient superimposed at depth of 1.59 m; density, 0.575 kg/L.																
T20E	7/09/73	7.50			Snow							5.67				1.83	0.60	E	1.10		1.10	1.09
M52A	8/24/73	5.79			SIce	0.12		0.12		1	5.67	5.67	0.90	5.10	0.00	0.12	0.90	E	0.11		0.11	0.10
	9/20/73	(Minimum balance)												4.95	-0.15				0.00		-0.15	-0.16
	10/01/73	(Hydrologic year ends)												4.95	-0.15				0.04			-0.12
M58A	10/12/73	5.72			Snow	0.38	0.27	0.38		1	5.34	5.50	0.90	4.95		0.22	0.324	M	0.07			
						Pit to dirty 1972 summer surface.																
							Probe stopped at top of a refrozen dense, wet, snow layer at the base of the snowpack, a false summer surface.														
								See 1974 measurement year for average *b'ss*.														
																			Average of 2 stakes:		-0.11	-0.08

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1974 MEASUREMENT YEAR																						
STAKE 73-21 (installed 4/17/73 from reused stakes; no 0- to 3-m section; 3- to 6-m labelled "72-1"; 6- to 9-m section has no label)																						
M52A	8/24/73	5.79			SIce	0.12		0.12		1	5.67											
	9/20/73	(Minimum balance)												4.95					0.00		0.00	
	10/01/73	(Hydrologic year begins)												4.95	0.00				0.04		0.04	0.00
M58A	10/12/73	5.72			Snow	0.38	0.27	0.38		1	5.34	5.50	0.90	4.95	0.00	0.22	0.324	M	0.07		0.07	0.03
		Pit to dirty 1972 summer surface.																				
		Probe stopped at the top of a frozen, dense, snow layer at the base of the snowpack; a false summer surface.																				
M60C	10/16/73	5.92			Snow		0.34	0.34	0.01	8	5.58	5.50	0.90	4.95	0.00	0.42	0.33	E	0.14		0.14	0.10
M5D	3/06/74	Stake buried.			Snow	2.17		2.17		1						2.17	0.39	M	0.85		0.85	0.81
M23A	6/08/74	Stake buried.			Snow	2.39		2.39		1						2.39	0.579	M	1.38		1.38	1.34
		Wet snow, 0.25 m slush, 0.05 m superimposed ice.																				
T42D	8/04/74	5.05			SIce	0.05		0.05		1	5.00	5.50	0.90	4.95	0.00	0.05	0.90	E	0.05		0.05	0.01
		Rough glacier surface causes large uncertainty of the summer surface height.																				
M50A	9/22/74	3.44			Ice								0.90	3.20	-1.75						-1.75	-1.79
	9/25/74	(Minimum balance)										3.56	0.90	3.20	-1.75				0.00		-1.75	-1.79
	9/30/74	(Hydrologic year ends)													-1.75				0.00			-1.79
T4	2/07/75	Stake buried.			Snow	2.90		2.90		1		3.56	0.90	3.20	-1.75	2.90	0.411	M	1.19			
T32A	8/17/75	3.70			SIce	0.14		0.14		1	3.56	3.56	0.90	3.20	-1.75	0.14	0.90	E	0.13			
1975 MEASUREMENT YEAR																						
STAKE 75-B (installed 2/06/75; located 330 m NNE of Site B.)																						
	9/25/74	(Minimum balance)												6.41					0.00		0.00	
	10/01/74	(Hydrologic year begins)												6.41	0.00				0.00		0.00	0.00
T2	2/06/75	9.70			Snow							7.12	0.90	6.41	0.00	2.58	0.41	E	1.06		1.06	1.06
T4	2/07/75	9.70	Assumed *b'*.		SIce	2.90		2.90		1		7.12	0.90	6.41	0.00	2.58	0.411	M	1.06		1.06	1.06
		Ice (firn) observed at 2.90-m depth; ice layer is 0.32 m above the summer surface observed 8/17/75.																				
M10D	6/03/75	10.62			Snow	4.31						7.12	0.90	6.41	0.00	3.50	0.56	M	1.96		1.96	1.96
		Snow pit located near Site B, 300 m from this stake.																				
		Transient superimposed ice at base of snowpack; thickness, 0.20 m; dirt observed at 1974 summer surface.																				
T32A	8/17/75	7.26			SIce	0.14		0.14		1	7.12	7.12	0.90	6.41	0.00	0.14	0.90	E	0.13		0.13	0.13
		Transient superimposed ice thickness observed at the stake.																				
	9/27/75	(Minimum balance)												5.66	-0.75				0.00		-0.75	-0.75
	10/01/75	(Hydrologic year ends)												5.66	-0.75				0.06			-0.69
T50A	10/27/75	6.82			Snow	0.48	0.54	0.53	0.02	6	6.29	6.35	0.90	5.66		0.47	0.32	M	0.15			
		Upper 0.03 m of frozen, old firn is dirty; density estimated, 0.9 kg/L.																				
		See 1976 measurement year for average *b'ss*.																				

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1976 MEASUREMENT YEAR																						
		STAKE 75-B (installed 2/06/75)																				
T32A	8/17/75	7.26			SIce	0.14		0.14		1	7.12	7.12										
		Transient superimposed ice thickness observed at the stake.																				
	9/27/75	(Minimum balance)												5.72					0.00		0.00	
	10/01/75	(Hydrologic year begins)												5.72	0.00				0.06		0.06	0.00
T50A	10/27/75	6.82			Snow	0.48	0.54	0.53	0.02	6	6.29	6.35	0.90	5.72	0.00	0.47	0.32	M	0.15		0.15	0.09
		Upper 0.03 m of frozen, old firn is dirty; density estimated, 0.9 kg/L.																				
T52A	10/28/75	6.79			Snow							6.35	0.90	5.72	0.00	0.44	0.31	E	0.14		0.14	0.08
	1/23/76	Augustine Volcano eruption; ashfall on Wolverine Glacier.																				
M6C,T4A	2/23/76	8.64			Snow	2.07	2.15	2.14	0.02	9	6.50	6.35	0.90	5.72	0.00	2.29	0.378	M	0.87		0.87	0.81
		Volcanic ash layer at depth of 0.39 m in the snow.																				
		Firn density estimated, 0.9 kg/L.																				
T5	2/25/76	8.70			Snow		2.44	2.44	0.05	10	6.26	6.35	0.90	5.72	0.00	2.35	0.39	E	0.92		0.92	0.86
M32	7/12/76	Stake not observed			Snow	0.97		0.97		1						0.97	0.671	M	0.65		0.65	0.59
		0.25 m superimposed ice on dirty 1975 summer surface.																				
M35	7/19/76	5.15			Ice								0.90	4.64	-1.08						-1.08	-1.14
	9/14/76	(Minimum balance)													-1.42				0.00		-1.42	-1.48
	9/30/76	(Hydrologic year ends)													-1.42				0.20			-1.28
T33	10/15/76	5.58			Snow	0.80		0.80		1	4.78	4.78	0.90	4.30	-1.42	0.80	0.33	M	0.26			
		STAKE 75-B2 (installed 10/27/75; inserted in snow to ice surface)																				
	9/27/75	(Minimum balance)												0.05					0.00		0.00	
	10/01/75	(Hydrologic year begins)												0.05	0.00				0.06		0.06	0.00
T50A	10/27/75	0.60			Snow	0.48	0.55	0.54	0.02	6	0.06	0.05	0.90	0.05	0.00	0.55	0.32	M	0.18			
		Top 0.03 m of underlying frozen old firn is dirty.; density estimated 0.9 kg/L.																				
T52	10/28/75	0.61			Snow		0.61	0.61		1	0.00	0.05	0.90	0.05	0.00	0.56	0.31	E	0.17		0.17	0.11
M6	2/23/76	2.20			Snow	2.07	2.15	2.14	0.02	9	0.06	0.05	0.90	0.05	0.00	2.15	0.378	M	0.81		0.81	0.75
		Volcanic ash layer at depth of 0.39 m.																				
		Underlying hard firn density visually estimated; 0.9 kg/L.																				
M32	7/12/76	0.95			Snow	0.97		0.97		1	-0.02	0.05	0.90	0.05	0.00	0.90	0.671	M	0.60		0.60	0.54
		0.70 m wet snow; 0.02 m slush; 0.25 m superimposed ice on 1975 summer surface.																				
M33	7/13/76	0.85	0.88		Snow							0.05	0.90	0.05	0.00	0.80	0.70	E	0.56		0.56	0.50

(1976 measurement year continued next page)

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE									
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1976 MEASUREMENT YEAR--Continued																						
		STAKE 76-B (installed 2/23/76)																				
	9/27/75	(Minimum balance)												4.14					0.00			
	10/01/75	(Hydrologic year begins)												4.14	0.00				0.06		0.06	0.00
T52	10/28/75				Snow		0.61	0.61		1						0.61	0.31	E	0.19		0.19	0.13
M6C,T4	2/23/76	6.87			Snow	2.07	2.15	2.14	0.02	9	4.73	4.60	0.90	4.14	0.00	2.27	0.378	M	0.86		0.86	0.80
T5C	2/25/76	6.91			Snow		2.44	2.44	0.05	10	4.47	4.60	0.90	4.14	0.00	2.31	0.39	E	0.90		0.90	0.84
M32	7/12/76	5.70			Snow	0.97		0.97		1	4.73	4.60	0.90	4.14	0.00	1.10	0.671	M	0.74		0.74	0.68
								Superimposed ice is 0.25 m thick on dirty surface.														
M33	7/13/76	5.55			Snow							4.60	0.90	4.14	0.00	0.95	0.671	E	0.64		0.64	0.58
	9/14/76	(Minimum balance)												2.58	-1.56				0.00		-1.56	-1.62
	9/30/76	(Hydrologic year ends)												2.58	-1.56				0.20			-1.62
T32A	10/15/76	3.67			Snow	0.80		0.80		1	2.87	2.87	0.90	2.58	-1.56	0.80	0.33	M	0.26			
																			Average of 2 stakes:		-1.49	-1.45

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS												SURFACE MASS BALANCE										
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn					Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b′*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b′ss*	*b′ss*	ρ	*b′(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1977 MEASUREMENT YEAR																						
		STAKE 76-B (installed 2/23/76)																				
	9/10/76	(Minimum balance)												2.59					0.00		0.00	
	10/01/76	(Hydrologic year begins)												2.59	0.00				0.20		0.20	0.00
T32A	10/15/76	3.67			Snow	0.80		0.80		1	2.87	2.88	0.90	2.59	0.00	0.79	0.33	M	0.26		0.26	0.06
		2.88			Ice						2.88	2.88	0.90	2.59	0.00							
T34C	10/20/76	3.84			Snow							2.88	0.90	2.59	0.00	0.96	0.32	E	0.31		0.31	0.11
M4,T4	2/23/77	Stake buried.			Snow		7.03	7.03	0.10	5						7.03	0.45	E	3.16		3.16	2.96
M9	2/26/77	Stake buried.			Snow		7.00	7.00		1						7.00	0.45	m	3.15		3.15	2.95
		Snow pit at estimated stake location.				Shovel broke at depth of 4.00 m; average density above 4.0-m depth, 0.398 kg/L.																
M36B	6/11/77	Stake buried.				5.90		5.90		1						5.90	0.57	M	3.36		3.36	3.16
	9/27/77	(Minimum balance)																	0.13	0.13	0.13	-0.07
	9/30/77	(Hydrologic year ends)																	0.30	0.13		0.23
M82B	10/24/77	4.60			Snow	1.52		1.52		1	3.08	3.08				1.52	0.294	M	0.45			
		3.08			NFirn							2.88				0.20	0.65	m	0.13	0.13		
		0.09-m sample depth in extremely hard, frozen, new firn; density, 0.65 kg/L.																	Less than 0.01 m is water.			
		2.88			Ice							2.88	0.90	2.59	0.00							
		b′ of Ice at stake measured 10/15/76.																				
		STAKE 77-B (installed 2/23/77 near site B)																				
	9/10/76	(Minimum balance)													0.00				0.00		0.00	
	10/01/76	(Hydrologic year begins)													0.00				0.30		0.30	0.00
M4,T3	2/23/77	4.76			Snow		7.05	6.90	0.10	1	-2.14	-2.14			0.00	6.90	0.46	E	3.17		3.17	2.87
M8C	2/25/77	Stake buried.			Snow		7.00	7.00	0.00	2					0.00	7.00	0.46	E	3.22		3.22	2.92
M9	2/26/77	Stake buried.			Snow		7.00	7.00		1					0.00	7.00	0.46	m	3.22		3.22	2.92
		Pit to 4.0-m depth near buried stake 76-B; stake not found.																				
M32B	6/07/77	4.71			Snow							-1.41			0.00	6.12	0.51	E	3.12		3.12	2.82
T33	6/08/77	4.65			Snow							-1.41			0.00	6.06	0.51	E	3.09		3.09	2.79
M36	6/11/77				Snow	5.90		5.90		1						5.90	0.57	M	3.36		3.36	3.06
		Pit to 1.0 m; core to 5.9 m, which is the upper surface of dirty, iced, firn, the 1976 summer surface.																				
M37B	6/12/77	4.50			Snow		5.91	5.91	0.01	3	-1.41	-1.41			0.00	5.91	0.51	E	3.01		3.01	2.71
											Base of stake settling with the snowpack as it compresses.											
		End of measurement year.																			----	----
M82B	10/24/77	Stake not found.			Snow	1.52		1.52		1						1.52	0.294	M	0.45		0.45	0.15
		Snow slightly colder than 0°C. Moderately dirty 1976 summer surface at top of firn.																				

(1977 measurement year continued next page)

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS												SURFACE MASS BALANCE										
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn			Yearly Results		
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1977 MEASUREMENT YEAR--Continued																						
		STAKE 77-B2 (installed 6/07/77)																				
	9/10/76	(Minimum balance)																	0.00		0.00	
	10/01/76	(Hydrologic year begins)													0.00				0.30		0.30	0.00
M32B	6/07/77	10.00			Snow							3.85	0.90	3.47	0.00	6.15	0.51	E	3.14		3.14	2.84
T33A	6/08/77	9.94			Snow		6.74	6.74	0.25	4		3.85	0.90	3.47	0.00	6.09	0.51	E	3.11		3.11	2.81
						Probing 30 m down glacier from the stake, probably into underlying firn.																
M36B	6/11/77				Snow	5.90		5.90				3.85	0.90	3.47	0.00	5.90	0.57	M	3.36		3.36	3.06
						Pit to 1.0 m; core to top of dirty, iced, firn at 5.9 m; the 1976 summer surface.																
M37B	6/12/77	9.76			Snow		5.91	5.91	0.12	8	3.85	3.85	0.90	3.47	0.00	5.91	0.57	E	3.37		3.37	3.07
	9/27/77	(Minimum balance)			Snow/Firn														0.16	0.16	0.16	-0.14
	9/30/77	(Hydrologic year ends)																	0.03	0.16		-0.11
M82B	10/24/77	5.62	5.62		Snow	1.52		1.52		1	4.10	4.10				1.52	0.294	M	0.45			
						Snow slightly colder than 0°C. Moderately dirty 1976 summer surface at top of firn.																
					NFirn							3.85				0.25	0.65	m	0.16	0.16		
						0.09-m sample depth in extremely hard, frozen, new firn; density, 0.65 kg/L.													Less than 0.01 m is water.			
																			Average of 2 stakes:		0.15	0.06

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b′*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b′ss*	Summer Surface Average *b′ss*	Old Firn and Ice Density *ρ*	Stake *b′(i)*	Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1978 MEASUREMENT YEAR											
		STAKE 76-B (installed 2/23/76)																				
	9/27/77	(Minimum balance)												0.00					0.00		0.00	
	10/01/77	(Hydrologic year begins)												0.00	0.00				0.03		0.03	0.00
M82B	10/24/77	4.60			Snow	1.52		1.52		1	3.08	3.08		0.00	0.00	1.52	0.294	M	0.45		0.45	0.42
					OFirn			0.20			2.88	2.88	0.65	0.13								
					0.09-m sample depth in extremely hard, frozen, new firn; density, 0.65 kg/L.																	
		2.88			Ice								0.90	2.59								
		b′ of ice at stake measured 10/15/76.												Stake summary								
														2.72	m(w) Old firn and Ice							
M115	9/30/78	2.44			Ice								0.90	2.20	-0.52						-0.52	-0.55
		Stake bent at 3.3 m.																				
	9/30/78	(Hydrologic year ends and minimum balance)																	0.00		-0.52	-0.55
		STAKE 77-B2 (installed 6/07/77)																				
	9/27/77	(Minimum balance)																	0.00		0.00	
	10/01/77	(Hydrologic year begins)												3.52	0.00				0.03		0.03	0.00
M82B	10/24/77	5.62			Snow	1.52		1.52		1	4.10	3.91	0.90	3.52	0.00	1.71	0.294	M	0.50		0.50	0.47
M2	2/28/78	8.23			Snow							3.91	0.90	3.52	0.00	4.32	0.37	E	1.60		1.60	1.57
M2B	3/01/78	8.18			Snow	4.03	4.31	4.29	0.04	13	3.89	3.91	0.90	3.52	0.00	4.27	0.374	M	1.60		1.60	1.57
T6					Pit to dirty 1977 summer surface.																	
M22	6/02/78	8.68			Snow							3.91	0.90	3.52	0.00	4.77	0.51	E	2.43		2.43	2.40
M115	9/30/78	3.50			SFirn								0.90	3.15	-0.37						-0.37	-0.40
		Stake bent at 4.6 m.																				
	9/30/78	(Hydrologic year ends and minimum balance)													-0.37				0.00		-0.37	-0.40
		STAKE 78-3.7B (installed 3/01/78)																				
	9/27/77	(Minimum balance)												5.13					0.00		0.00	
	10/01/77	(Hydrologic year begins)												5.13	0.00				0.03		0.03	0.00
M2B	3/01/78	9.98			Snow	4.03	4.31	4.28	0.04	11	5.70	5.70	0.90	5.13	0.00	4.28	0.374	M	1.60		1.60	1.57
					Pit to dirty 1977 summer surface.																	
M22	6/02/78	10.30			Snow							5.70	0.90	5.13	0.00	4.60	0.51	E	2.35		2.35	2.32
T112	9/29/78	5.24			SIce	0.03		0.03			5.21	5.21	0.90	4.72	-0.41	0.03	0.90	E	0.03		-0.38	-0.41
					75% of area is covered with superimposed ice that is 0.05 m thick.																	
					25% of area is exposed Mt. Augustine volcanic ash; the 1976 summer surface.																	
	9/30/78	(Hydrologic year ends and minimum balance)												4.67	-0.46				0.00		-0.46	-0.49
T1	3/07/79	7.94			Snow	2.67	2.76	2.75	0.01	11	5.19	5.19	0.90	4.67		2.75	0.404	M	1.11			
																					-0.45	-0.48

Average of 3 stakes:

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----													<-----SURFACE MASS BALANCE-----									
		<---Stake Reading--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice--->			<-----Snow and New Firn----->					Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1979 MEASUREMENT YEAR																						
		STAKE 78-3.7B (installed 3/01/78)																				
T112	9/29/78	5.24			SIce	0.03		0.03		1	5.21	5.21										
						75% of area covered with superimposed ice that is 0.05 m thick.																
						25% of area is exposed Mt. Augustine volcanic ash; 1976 ss.																
	10/01/78	(Hydrologic year begins and minimum balance)												4.67	0.00				0.00		0.00	0.00
T2	3/07/79	7.94			Snow	2.67	2.76	2.75	0.01	11	5.19	5.19	0.90	4.67	0.00	2.75	0.404	M	1.11		1.11	1.11
M101	8/06/79	4.83			SIce	0.03		0.03		1	4.80	4.80	0.90	4.32	-0.35	0.03	0.90	E	0.03		-0.32	-0.32
						This year's superimposed ice covers 30 % of area. 70 % is exposed "superfirn", superimposed ice in old firn.																	
		STAKE 79-3.7B (installed 3/07/79)																				
	10/01/78	(Hydrologic year begins and minimum balance)												5.66	0.00				0.00		0.00	0.00
T2	3/07/79	9.04			Snow	2.67	2.76	2.75	0.01	11	6.29	6.29	0.90	5.66	0.00	2.75	0.404	M	1.11		1.11	1.11
M100	8/06/79	6.03			SFirn	0.10		0.10		1	5.93	5.93	0.90	5.34	-0.32	0.10	0.90	E	0.09		-0.23	-0.23
	9/24/79	(Minimum balance)													-2.38				0.00		-2.38	-2.38
	9/30/79	(Hydrologic year ends)													-2.38				0.11			-2.27
T2	1/10/80	6.75			Snow	2.78		3.11		11	3.64	3.64	0.90	3.28	-2.38	3.11	0.40	E	1.24			
		3.97			Ice						3.64	3.64	0.90	3.28	-2.38							
		Ice surface observed in snow pit at stake. Average *d* and *b'ss* include the 1/11/80 probing data.																				
M3A	1/11/80				Snow		3.14	3.14	0.14	10						3.14	0.40	E	1.26			

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1980 MEASUREMENT YEAR																						
		STAKE 79-3.7B (installed 3/07/79)																				
M100	8/06/79	6.03			SFirn	0.10		0.10		1	5.93	5.93										
	9/24/79	(Minimum balance)												3.28					0.00		0.00	
	10/01/79	(Hydrologic year begins)												3.28	0.00				0.11		0.11	0.00
T2	1/10/80	6.75			Snow	2.78		3.11		11	3.64	3.64	0.90	3.28		3.11	0.40	E	1.24			
		3.97			Ice						3.64	3.64	0.90	3.28								
		Ice surface observed in snow pit at stake. Average *d* and *b'ss* include the 1/11/80 probing data.																				
M3A	1/11/80				Snow		3.14	3.14	0.14	10						3.11	0.40	E	1.24			
M38	6/05/80	Stake buried.			Snow		4.20	4.20		1						4.20	0.52	E	2.18		2.18	2.07
M87	9/05/80	5.86			Snow							3.64	0.90	3.28	0.00	2.22	0.60	m	1.33	1.28	1.33	1.22
		Pit to 0.60-m depth; density, 0.60 kg/L.																				
	9/30/80	(Hydrologic year ends and minimum balance)																	0.90	0.87	0.87	0.76
																			Difference of 0.03 is water.			
		STAKE 80-3.7B, also referred to as STAKE 80-B (installed 1/10/80)																				
	9/24/79	(Minimum balance)												4.49					0.00		0.00	
	10/01/79	(Hydrologic year begins)												4.49	0.00				0.11		0.11	0.00
T2	1/10/80	8.10			Snow	2.78		2.78		1	5.32	4.99	0.90	4.49	0.00	3.11	0.40	E	1.24		1.24	1.13
M3A	1/11/80	8.10 (Assumed)			Snow		3.14	3.14	0.14	10	4.96	4.99	0.90	4.49	0.00	3.11	0.40	E	1.24		1.24	1.13
M38	6/05/80	Stake buried.			Snow		4.20	4.20		1						4.20	0.52	E	2.18		2.18	2.07
M85	9/03/80	7.25			Snow							4.99	0.90	4.49	0.00	2.26	0.60	E	1.36		1.36	1.25
M87	9/05/80	7.34			Snow							4.99	0.90	4.49	0.00	2.35	0.60	m	1.41	1.36	1.41	1.30
		Pit to 0.60-m depth; density, 0.60 kg/L.																				
	9/30/80	(Hydrologic year ends and minimum balance) Snow melt after 9/05/80 estimated from weather data.																	0.98	0.95	0.95	0.84
																			Difference of 0.03 is water.			
M98, M102	9/01/82	3.70		3.64	OFirn																	
		STAKE 80-B2 (installed 6/06/80 by driving into snow to the ice surface)																				
M40	6/06/80	5.61			Snow		5.61	5.61		1	0.00	0.00			0.00	5.61	0.51	E	2.86		2.86	2.75
M85	9/03/80	1.66			Snow							0.00			0.00	1.66	0.60	m	1.00		1.00	0.89
M87	9/05/80	1.75			Snow							0.00			0.00	1.75	0.60	m	1.05		1.05	0.94
		Pit to 0.60-m depth; density, 0.60 kg/L. Snow melt estimated from weather data.																				
	9/30/80	(Hydrologic year ends and minimum balance) Snow melt after 9/05/80 estimated from weather data.																				
					NFirn							0.00			0.00	1.03	0.60	E	0.62	0.60	0.60	0.49
												b'ss estimated from new firn balance.							Difference of 0.02 is water.			
T100	9/01/81	2.62			Snow							1.03				1.59	0.60	E	0.95			
M98, M102	9/01/82	1.10		1.11	OFirn																	
																			Average of 3 stakes:		0.81	0.70

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<----------OBSERVATIONS---------->												<----------SURFACE MASS BALANCE---------->									
		<---------Stake Reading--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice--->			<-------Snow and New Firn-------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1981 MEASUREMENT YEAR																						
		STAKE 81-B (installed by pounding it through the snow to firn, 1/26/81)																				
	10/01/80	(Hydrologic year begins and minimum balance)												0.00	0.00				0.00		0.00	0.00
M6	1/26/81	5.33			Snow		5.11	5.11	0.10	17	0.22	0.23	0.60	0.14	0.00	5.10	0.42	E	2.14		2.14	2.14
M7	1/27/81	5.28			Snow		5.00	5.00	0.02	4	0.28	0.23	0.60	0.14	0.00	5.05	0.42	E	2.12		2.12	2.12
M40	6/02/81	5.48			Snow							0.23	0.60	0.14	0.00	5.25	0.50	E	2.63		2.63	2.63
RM13	6/03/81	5.48		5.42	Snow							0.23	0.60	0.14	0.00	5.25	0.50	m	2.63		2.63	2.63
		Pit in wet snow to 1.20-m, depth; density, 0.58 kg/L; snow probably not entirely wet.																				
M42	6/07/81	5.50			Snow							0.23	0.60	0.14	0.00	5.27	0.50	E	2.64		2.64	2.64
T100	9/01/81	1.91		1.89	Snow assumed.							0.23	0.60	0.14	0.00	1.66	0.57	E	0.95		0.95	0.95
	9/24/81	(Minimum balance)																	0.93	0.89	0.89	0.89
T103	9/25/81	Glacier observed to be covered with fresh snow above 900-m altitude.																	Difference of 0.05 m is water.			
	10/01/81	(Hydrologic year ends)																	0.03	0.89		0.92
M8,T11	1/20/82	4.04		3.96	Snow	2.10		2.10		1	1.86	1.86				2.10	0.435	M	0.91			
					NFirn							0.23	0.90	0.21		1.63	0.57	E	0.93	0.89		
		Pit to new firn; 0.24-m thick depth-hoar at base of snow.																				

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	*b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Obsvd. *b'ss*	Average *b'ss*	Density *ρ*	Stake *b'(i)*	Ice *b(i)*	Depth *d*	Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1982 MEASUREMENT YEAR																						
		STAKE 81-B (installed by pounding through snow to ice, 1/26/81)											Stake summary									
T100	9/01/81	1.91		1.89	Snow assumed.							0.23	Firn	0.89								
	9/24/81	(Minimum balance)											Ice	0.21					0.00		0.00	
													Total	1.10								
	10/01/81	(Hydrologic year begins)												1.10	0.00				0.03		0.03	0.00
M9,T11	1/20/82	4.04		3.96	Snow	2.10		2.10		1	1.86	1.86	2 layers	1.10	0.00	2.10	0.435	M	0.91		0.91	0.88
					Pit to new firn; 0.24-m thick depthhoar at base of snow.																	
					OFirn			1.63	Firn depth			0.23										
M39	6/26/82			3.68	Snow							1.86	2 layers	1.10	0.00	1.82	0.51	E	0.93		0.93	0.90
M98	9/01/82	0.55		0.62	OFirn							0.23	2 layers	0.44	-0.66						-0.66	-0.69
					Wood chips found on the surface from installing plug in the stake bottom.																	----	----
		STAKE 81-B2 (installed 9/02/81)																				
RM33	9/02/81	3.80		3.81	Snow assumed.																	
	9/24/81	(Minimum balance)												2.67	0.00				0.00		0.00	
	10/01/81	(Hydrologic year begins)												2.67	0.00				0.03		0.03	0.00
M8,T11	1/20/82	5.73		5.61	Snow	2.10		2.10		1	3.51	3.51	2 layers	2.67	0.00	2.10	0.435	M	0.91		0.91	0.88
M40	6/26/82	5.24		5.25	Snow							3.51	2 layers	2.67	0.00	1.74	0.53	E	0.92		0.92	0.89
M98	9/01/82	2.23		2.21	OFirn							3.51	2 layers	2.02	-0.65						-0.65	-0.68
					Ice							1.86										
	9/28/82	(Minimum balance)												1.67	-1.00						-1.00	-1.03
	9/30/82	(Hydrologic year ends)												1.67	-1.00				0.02			-1.01
T54	11/06/82	2.73			Snow		0.92	0.92	0.01	10	1.81	1.86	0.90	1.67		0.87	0.32	E	0.28			
												See 1983 measurement year for average *b'ss.*										

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE										
		Stake Reading				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn					Yearly Results	
Field Notes	Date	Tape b'	Survey b^*	Survey b^{**}	Stratum	Pit/Core d	Probe d	Average d	$s.e.$	n	Obsvd. $b'ss$	Average $b'ss$	Density ρ	Stake $b'(i)$	Ice $b(i)$	Depth d	Density ρ		Snow $b(s)$	NFirn $b(f)$	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1983 MEASUREMENT YEAR																							
		STAKE 81-B2 (installed 9/02/81)																					
M99	9/01/82	2.23		2.21	OFirn									2.02									
	9/28/82	(Minimum balance)												1.67					0.00		0.00		
	10/01/82	(Hydrologic year begins)												1.67	0.00				0.02		0.02	0.00	
T54	11/06/82	2.73			Snow		0.92	0.92	0.01	10	1.81	1.86	0.90	1.67	0.00	0.87	0.32	E	0.28		0.28	0.26	
M8	1/14/83	4.41		4.41	Snow		2.62	2.62		10	1.79	1.86	0.90	1.67	0.00	2.55	0.37	m	0.94		0.94	0.92	
						Pit to 1.20 m.																	
M24,M26	6/13/83	4.67	4.67	4.65	Snow		2.66	2.66	0.05	10	1.99	1.86	0.90	1.67	0.00	2.81	0.56	m	1.57		1.57	1.55	
T69	9/01/83	1.01		1.12	OFirn			Magnet and wood chips found at surface.					0.90	1.01	-0.66						-0.66	-0.68	
T71	9/02/83	0.93		1.04	OFirn								0.90	0.94	-0.73						-0.73	-0.75	
					Old firn is water soaked; density assumed to be 0.9 kg/L.																		
		STAKE 83-B (installed 6/13/83)																					
	9/28/82	(Minimum balance)																	0.00		0.00		
	10/01/82	(Hydrologic year begins)												5.36	0.00				0.02		0.02	0.00	
M26	6/13/83	8.61		8.61	Snow		2.66	2.66	0.05	10	5.95	5.95	0.90	5.36	0.00	2.66	0.57	m	1.52		1.52	1.50	
						Pit to 1.20-m depth; slush below; density, 0.55 kg/L.																	
		0.23 m superimposed ice.																					
T69	9/01/83	5.00			SFirn								0.90	4.50	-0.86						-0.86	-0.88	
T71	9/02/83	5.03			SFirn								0.90	4.53	-0.83						-0.83	-0.85	
	9/22/83	(Minimum balance)												4.35	-1.01				0.00		-1.01	-1.03	
	9/30/83	(Hydrologic year ends)												4.35	-1.01				0.01			-1.02	
M66	11/14/83	6.01			Snow							4.83	0.90	4.35		1.18	0.33	E	0.39				
												See 1984 measurement year for average $b'ss$.											
1984 MEASUREMENT YEAR																							
		STAKE 83-B (installed 6/13/83)																					
T71	9/02/83	5.03			SFirn								0.90	4.53									
	9/22/83	(Minimum balance)												4.35					0.00		0.00		
	10/01/83	(Hydrologic year begins)												4.35	0.00				0.01		0.01	0.00	
M66	11/14/83	6.01			Snow							4.83	0.90	4.35	0.00	1.18	0.33	E	0.39		0.39	0.38	
M7	1/18/84	7.45			Snow							4.83	0.90	4.35	0.00	2.62	0.39	E	1.02		1.02	1.01	
M7	1/19/84	7.41		7.38	Snow	2.58	2.53	2.55	0.01	15	4.83	4.83	0.90	4.35	0.00	2.55	0.39	M	0.99		0.99	0.98	
M10	1/19/84					5 cores to ice; pit to 1.20-m depth; density, 0.37 kg/L.																	
M21	6/08/84	7.58	7.58	7.56	Snow							4.83	0.90	4.35	0.00	2.73	0.51	E	1.39		1.39	1.38	
M40	8/20/84	4.15		4.15	Ice								0.90	3.74	-0.61						-0.61	-0.62	
	9/30/84	(Hydrologic year ends)												3.17	-1.18				0.00		-1.18	-1.19	
	10/02/84	(Minimum balance)												3.15	-1.20				0.00		-1.20		
T67	10/30/84	3.74			Snow		0.24	0.24	0.02	13	3.50	3.50	0.90	3.15		0.24	0.30	E	0.07				

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1985 MEASUREMENT YEAR																						
		STAKE 83-B (installed 6/13/83)																				
M40	8/20/84	4.15		4.15	Ice								0.90	3.74								
	10/01/84	(Hydrologic year begins)												3.17	0.00				0.00			0.00
	10/02/84	(Minimum balance)												3.13	-0.04				0.00		0.00	-0.04
T67	10/30/84	3.74			Snow		0.24	0.24	0.02	13	3.50	3.48	0.90	3.13	-0.04	0.26	0.30	E	0.08		0.08	0.04
RM6	1/12/85	5.55	5.56	5.56	Snow		2.05	2.05	0.02	15	3.51	3.48	0.90	3.13	-0.04	2.08	0.37	E	0.77		0.77	0.73
RM12	1/13/85	5.41	5.44	5.44	Snow							3.48	0.90	3.13	-0.04	1.96	0.37	E	0.73		0.73	0.69
M52	6/15/85	6.59	6.59	6.54	Snow							3.48	0.90	3.13	-0.04	3.06	0.51	E	1.56		1.56	1.52
RM75	8/27/85	3.59	3.62	3.61	SFirn		0.19	0.19	0.02	12	3.42	3.48	0.90	3.13	-0.04	0.13	0.90	E	0.12		0.12	0.08
	9/17/85	(Minimum balance)												2.98	-0.19				0.00		-0.15	-0.19
	9/30/85	(Hydrologic year ends)												2.98	-0.19				0.23			0.04
M10	2/18/86		7.11	7.00	Snow			3.69	0.24	2	3.31	3.31	0.90	2.98		3.69	0.41	E				
		Average of snow depths measured at Stakes 85-BBQ and 85-BP.																				
		STAKE 85-BBQ (installed 6/15/85) Located 110 m east of measurement site.												Ice balance continued from stake 83-B.								
M52	6/15/85	7.79	8.07		Snow							4.76	0.90	4.28	-0.04	3.03	0.51	E	1.55		1.55	1.51
		Surveyed *b** is above the snow surface.																				
RM76	8/27/85	4.95			SFirn		0.19	0.19	0.02	12	4.76	4.76	0.90	4.28	-0.04	0.19	0.90	E	0.17		0.17	0.13
	9/17/85	(Minimum balance)												4.00	-0.32				0.00		-0.28	-0.32
	10/01/85	(Hydrologic year ends)													-0.32				0.23			-0.09
M11	2/18/86	7.89			Snow		3.45	3.45		1	4.44	4.44	0.90	4.00		3.45	0.41	E	1.41			
		Stake bent at 7.5 m.																				
		STAKE 85-BP (installed 6/14/85)												Ice balance continued from stake 83-B.								
M52	6/14/85	7.77			Snow							4.66	0.90	4.19	-0.04	3.11	0.51	E	1.59		1.59	1.55
M52	6/15/85	7.73	7.74	7.72	Snow							4.66	0.90	4.19	-0.04	3.06	0.51	E	1.56		1.56	1.52
RM75	8/27/85	4.85	4.86	4.85	SFirn		0.19	0.19	0.02	12	4.66	4.66	0.90	4.19	-0.04	0.19	0.90	E	0.17		0.17	0.13
	9/17/85	(Minimum balance)												4.03	-0.20				0.00		-0.16	-0.20
	10/01/86	(Hydrologic year ends)												4.03	-0.20				0.23			0.03
M10	2/18/86		8.44	8.41	Snow		3.93	3.93	0.03	2	4.48	4.48	0.90	4.03		3.93	0.41	E	1.61			
																					Average of 3 stakes:	-0.20	-0.01

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<----------OBSERVATIONS----------												<----------SURFACE MASS BALANCE----------									
		<---------Stake Reading--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice--->			<-------Snow and New Firn-------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b′*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b′ss*	*b′ss*	*ρ*	*b′(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1986 MEASUREMENT YEAR																						
		STAKE 83-B (installed 6/13/83)																				
RM75	8/27/85	3.59	3.62	3.61	SFirn		0.19	0.19	0.02	12	3.42											
	9/17/85	(Minimum balance)												2.98					0.00		0.00	
	10/01/85	(Hydrologic year begins)												2.98	0.00				0.23		0.23	0.00
M10	2/18/86		7.11	7.00	Snow			3.69			3.31	3.31	0.90	2.98	0.00	3.69	0.41	E	1.51		1.51	1.28
		Average of snow depths measured at Stakes 85-BBQ and 85-BP.																				
T12	2/19/86		7.03	6.94	Snow							3.31	0.90	2.98	0.00	3.63	0.41	E	1.49		1.49	1.26
RM19	6/16/86	6.07	6.22	6.00	Snow							3.31	0.90	2.98	0.00	2.69	0.51	E	1.37		1.37	1.14
T50	8/20/86	2.18	2.79	2.81	Ice								0.90	1.96	-1.02						-1.02	-1.25
		The apparent *b** is 0.61 m above the ice surface, which was not visible from the survey instrument; use the *b′* value.																				
	9/30/86	(Hydrologic year ends)																			----	----
	10/03/86	(Minimum balance)																	0.00		----	----
RM2	2/10/87	Stake buried			Snow		3.90	3.90	0.12	9						3.90	0.42	E	1.64			
		STAKE 85-BBQ (installed 6/15/85)																				
RM76	8/27/85	4.95			Snow		0.19	0.19	0.02	12	4.76											
	9/17/85	(Minimum balance)												4.00	0.00				0.00		0.00	
	10/01/85	(Hydrologic year begins)												4.00	0.00				0.23		0.23	0.00
M11	2/18/86	7.89			Snow		3.45	3.45		1	4.44	4.44	0.90	4.00	0.00	3.45	0.41	E	1.41		1.41	1.18
RM20	6/16/86	7.20			Snow							4.44	0.90	4.00	0.00	2.76	0.51	E	1.41		1.41	1.18
T50	8/20/86	4.05	4.31		Ice								0.90	3.65	-0.35						-0.35	-0.58
		Surveyed *b** at stake and *b′* different by 0.26 m; distance of survey was 141 m; use *b′*.																				
	9/30/86	(Hydrologic year ends)																			----	----
	10/03/86	(Minimum balance)																	0.00		----	----
RM2	2/10/87	Stake buried.					3.90	3.90	0.12	9	Snow hard below depth of 3.0 m.					3.90	0.41	E	1.60			
		STAKE 86-BL (installed 2/18/86)																				
T11	2/18/86		3.93	3.93	Snow		No snow depth measurement; stake reading is likely the snow depth, but not recorded in the notes.															
RM19	6/16/86	2.90	3.03	3.03	Snow																	
T155	10/03/89	1.25			Ice																	
		STAKE 85-BP (installed 6/14/85)																				
RM75	8/27/85	4.85	4.86	4.85	Snow		0.19	0.19	0.02	12	4.66											
	9/17/85	(Minimum balance)												4.03					0.00		0.00	
	10/01/85	(Hydrologic year begins)												4.03	0.00				0.23		0.23	0.00
M10	2/18/86		8.44	8.41	Snow		3.93	3.93	0.03	2	4.48	4.48	0.90	4.03	0.00	3.93	0.41	E	1.61		1.61	1.38
RM20	6/16/86	7.37	7.37	7.35	Snow							4.48	0.90	4.03	0.00	2.87	0.51	E	1.46		1.46	1.23
T49	8/20/86	4.00	3.99	3.98	SFirn								0.90	3.58	-0.45						-0.45	-0.68
T155	10/03/89	1.21			Ice																	

(1986 measurement year continued next page)

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape b'	Survey b^*	Survey b^{**}	Stratum	Pit/Core d	Probe d	Snow Depth Average d	s.e.	n	Summer Surface Obsvd. $b'ss$	Summer Surface Average $b'ss$	Old Firn and Ice: Density ρ	Old Firn and Ice: Stake $b'(i)$	Old Firn and Ice: Ice $b(i)$	Snow and New Firn: Depth d	Snow and New Firn: Density ρ		Snow $b(s)$	NFirn $b(f)$	Yearly Results: Net b_n	Yearly Results: Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1986 MEASUREMENT YEAR--Continued																						
		STAKE 86-B (installed 6/16/86)																				
RM 20	6/16/86	8.69			Snow			2.77			5.92	5.92	0.90	5.33	0.00	2.77	0.51	E	1.41		1.41	1.18
		Snow depth is the average of Stakes 83-B, 85-BBQ, and 85-BP.																				
T49	8/20/86	5.47	5.48	5.48	SFirn								0.90	4.93	-0.40						-0.40	-0.63
		Mass balance 8/20/86 to 10/03/89 measured. Balance from 8/20/86 to 10/03/86 estimated by subtracting the total balance after 10/03/86 measured at stake 87-B.																				
						Date	Stake b'	Change in b'														
						8/20/86	5.48		Obsvd.													
						10.03.86	(3.67)	(1.81)	(Calc.)													
						9/17/87	(4.39)	0.72														
						9/21/88	(5.04)	0.65														
		STAKE 86-B (cont.)				10.03.89	2.48	-2.56														
												Summary of the information needed for the 1986 balance estimate.										
	9/30/86	(Hydrologic year ends)			Ice	(Calculated using weather data)								3.33	-2.00						-2.00	-2.23
	10/03/86	(Minimum balance)			Ice	(Calculated from the stake data)						3.67	0.90	3.30	-2.03						-2.03	
	9/17/87	(Minimum balance)			NFirn	(Stake 87-B; new firn measured)						4.39				0.72				0.41		
M47,RM23	10/01/87				Snow	0.47	0.65	0.61	0.05	4						0.61	0.316	M				
		Stake bent over almost flat; survey of bent stake; no stake reading.																				
	9/21/88	(Minimum balance)			NFirn	(Stake 87-B; new firn measured)						5.04				0.65				0.37		
89T155	10/03/89	2.48			Ice	(Stake 87-B; ice loss measured)																
1987 MEASUREMENT YEAR																						
		STAKE 87-B (installed 6/13/87)																				
	10/01/86	(Hydrologic year begins)													0.00				0.00			0.00
	10/03/86	(Minimum balance)													-0.03				0.00		0.00	-0.03
RM2	2/10/87	All stakes buried.			Snow		3.56	3.56	0.37	9					-0.03	3.56	0.41	E	1.46		1.46	1.43
T28	6/13/87	9.20			Snow		4.34	4.34	0.04	6	4.86	4.86	0.90	4.37	-0.03	4.34	0.55	E	2.39		2.39	2.36
	9/17/87	(Minimum balance)													-0.03				0.43	0.41	0.41	0.38
																			Difference of 0.02 m is water.			
	9/30/87	(Hydrologic year ends)													-0.03				0.20	0.41		0.58
M47,RM23	10/01/87		6.22	6.21	Snow	0.47	0.65	0.61	0.05	4	5.60	5.58				0.63	0.316	M	0.20			
					NFirn							4.86	0.90	4.37		0.72	0.60	E	0.43	0.41		
												See 1988 measurement year for average $b'ss$.										

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1988 MEASUREMENT YEAR																						
													Stake summary									
													Firn	0.43								
													Ice	4.37								
		STAKE 87-B (installed 6/13/87)											Total	4.80								
	9/10/87	(Minimum balance)												4.80					0.00		0.00	
	10/01/87	(Hydrologic year begins)												4.80	0.00				0.20		0.20	0.00
M47	10/01/87		6.22	6.21	Snow	0.47	0.65	0.61	0.05	4	5.60	5.58	2 layers	4.80	0.00	0.63	0.316	M	0.20		0.20	0.00
M2	3/17/88	11.45	11.40	11.40	Snow		6.09	6.09	0.13	7	5.31	5.58	2 layers	4.80	0.00	5.82	0.45	E	2.62		2.62	2.42
		Pit dug in the snow at the predicted stake location; the metal stake was found in the pit wall using a pocket compass.																				
M5	3/18/88	11.35			Snow							5.58	2 layers	4.80	0.00	5.77	0.45	E	2.60		2.60	2.40
RM10	6/10/88	10.60		10.59	Snow							5.58	2 layers	4.80	0.00	5.02	0.59	m	2.96		2.96	2.76
		McCall-tube core to depth of 2.74 m; density, 0.574 kg/L.																				
M29.5	9/17/88	6.41	6.39	6.36	Snow	0.30	0.73	0.52	0.22	2	5.84	5.58	2 layers	4.80	0.00	0.78	0.60	m	0.47			0.27
		Pit to depth of 0.30 m; density, 0.597 kg/L.																				
		Crevasse measurement: 0.73 m snow on about 1.0 m old firn; local variability is 0.5 m. Old firn overlays glacier ice.																				
	9/21/88	(Minimum balance)																	0.39	0.37	0.37	0.17
																			Difference of 0.02 m is water.			
	9/30/88	(Hydrologic year ends)																	0.02	0.37		0.19
T8	2/16/89	8.54	8.52	8.52	Snow	2.36	2.22	2.23	0.01	11	6.29	6.23				2.94	0.452	M	1.33			
					NFirn						5.58	5.58	2 layers	4.80		0.65	0.60	E	0.39	0.37		
		See 1989 measurement year for average *b'ss.*																				
1989 MEASUREMENT YEAR																						
													Stake summary									
													Firn	0.80								
													Ice	4.37								
		STAKE 87-B (installed 6/12/87)											Total	5.17								
M29.5	9/17/88	6.41	6.39	6.36	Snow	0.30	0.73	0.52	0.36	2	5.84	5.58										
		Crevasse measurement: 0.73 m snow on about 1.0 m old firn; local variability is 0.5 m. Old firn overlays glacier ice.																				
	9/21/88	(Minimum balance)												5.19	Total old firn and ice.						0.00	
	10/01/88	(Hydrologic year begins)												5.19	0.00				0.02		0.02	0.00
T8	2/16/89	8.54	8.52	8.52	Snow	2.36	2.22	2.23	0.01	11	6.29	6.23	2 layers	5.19	0.00	2.29	0.452	M	1.04		1.04	1.02
T62	6/17/89	7.95	7.95	7.95	Snow		1.95	1.95	0.13	3	6.00	6.23	2 layers	5.19	0.00	1.72	0.50	E	0.86		0.86	0.84
	9/30/89	(Hydrologic year ends)										3.32	0.90	2.99	-2.20				0.00		-2.20	-2.22
T154	10/03/89		3.22	3.21	Ice							3.30	0.90	2.97	-2.22						-2.22	
	10/05/89	(Minimum balance)										3.27	0.90	2.94	-2.25				0.00		-2.25	
M25	6/03/90	5.25			Snow		1.97	1.97	0.05	10	3.28	3.27										

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----													<-----SURFACE MASS BALANCE-----										
		<---Stake Reading--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice--->			<-----Snow and New Firn----->					Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1990 MEASUREMENT YEAR																						
		STAKE 89-B2 (installed 10/08/89)																				
	10/01/89	(Hydrologic year begins)												5.28	0.00				0.00			0.00
	10/05/89	(Minimum balance)												5.23	-0.05				0.00		0.00	-0.05
T160	10/08/89	6.38	6.41	6.41	Snow	0.45		0.45		1	5.96	5.81	0.90	5.23	-0.05	0.60	0.30	E	0.18		0.18	0.13
	12/14/89	Redoubt Volcano began erupting; ash fell on Wolverine Glacier, Alaska.																				
T47	2/14/90	8.40	8.40	8.35	Snow							5.81	0.90	5.23	-0.05	2.54	0.39	E	0.99		0.94	0.94
T63	3/17/90	8.95			Snow							5.81	0.90	5.23	-0.05	3.14	0.41	E	1.29		1.24	1.24
M25	6/03/90	7.79	7.78	7.76	Snow		1.97	1.97	0.05	10	5.79	5.81	0.90	5.23	-0.05	1.95	0.55	m	1.07		1.02	1.02
		Volcanic ash layer at depth of 0.24-0.29 m in the snow.																				
M32	9/06/90		2.53	2.48	SFirn								0.90	2.28	-3.00						-3.00	-3.00
M36	9/11/90	2.45			SFirn								0.90	2.21	-3.07						-3.07	-3.07
	9/28/90	(Minimum balance)										2.40	0.90	2.16	-3.12				0.00		-3.07	-3.12
	9/30/90	(Hydrologic year ends)												2.16	-3.12				0.03			-3.09
M3	1/06/91	3.88	3.60	3.52	Snow	1.12	1.12	1.12	0.03	11	2.40	2.40	0.90	2.40		1.12	0.364	M	0.41			
1991 MEASUREMENT YEAR																						
		STAKE 89-B2 (installed 10/08/89)																				
M36	9/11/90	2.45			SFirn																	
	9/28/90	(Minimum balance)												2.16	0.00				0.00		0.00	
	10/01/90	(Hydrologic year begins)												2.16	0.00				0.03		0.03	0.00
M3	1/06/91	3.88	3.60	3.52	Snow	1.12	1.12	1.12	0.03	11	2.40	2.40	0.90	2.16	0.00	1.12	0.364	M	0.41		0.41	0.38
M17	5/13/91	Stake buried				3.12	3.31	3.29	0.05	11						3.29	0.398	M	1.31		1.31	1.28
M30	9/12/91	1.36	1.38	1.28	Ice								0.90	1.15	-1.01						-1.01	-1.04
		Stake abandoned.																				
		STAKE 91-B (installed 1/07/91)																				
	9/28/90	(Minimum balance)												5.79					0.00		3.63	
	10/01/90	(Hydrologic year begins)												5.79	0.00				0.03		0.03	0.00
M6	1/07/91	7.07			Snow		0.68	0.68	0.07	10	6.39	6.43	0.90	5.79	0.00	0.64	0.364	E	0.23		0.23	0.20
M17	5/13/91	9.78	9.77	9.77	Snow	3.12	3.33	3.31	0.05	11	6.46	6.43	0.90	5.79	0.00	3.34	0.398	M	1.33		1.33	1.30
M30	9/12/91	5.02	5.02	5.02	Ice								0.90	4.52	-1.27						-1.27	-1.30
	9/23/91	(Minimum balance)												4.45	-1.34				0.00		-1.34	-1.37
	9/30/91	(Hydrologic year ends)												4.45	-1.34				0.24			-1.10
M1,M2	1/22/92	8.08	8.12	8.12	Snow	3.15	3.18	3.18	0.02	11	4.94	4.94	0.90	4.45		3.18	0.355	M	1.13			

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	s.e.	n	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density ρ	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density ρ		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1992 MEASUREMENT YEAR																						
		STAKE 91-B (installed 1/07/91)				Merge with same stake data below																
M30	9/12/91	5.02	5.02	5.02	Ice																	
	9/23/91	(Minimum balance)												4.45					0.00		0.00	
	10/01/91	(Hydrologic year begins)												4.45	0.00				0.24		0.24	0.00
M2	1/22/92	8.08	8.12	8.12	Snow	3.15	3.18	3.18	0.02	11	4.94	4.94	0.90	4.45	0.00	3.18	0.355	M	1.13		1.13	0.89
M11	5/13/92	8.86	8.84	8.68	Snow							4.94	0.90	4.45	0.00	3.74	0.47	m	1.76		1.76	1.52
						McCall-tube core to depth of 2.51 m; density, 0.444 kg/L.																
M13	5/14/92	8.86			Snow							4.94				3.74						
M59	9/03/92	3.74	3.74	3.74	Ice								0.90	3.37	-1.08						-1.08	-1.32
	9/17/92	(Minimum balance)												3.26	-1.19				0.00		-1.19	-1.43
	9/30/92	(Hydrologic year ends)												3.26	-1.19				0.02			-1.41
M8	2/11/93	6.32			Snow		2.50	2.50	0.08	12	3.82	3.82				2.50	0.39	E	0.98			
1993 MEASUREMENT YEAR																						
		STAKE 91-B (installed 1/07/91)																				
M59	9/03/92	3.74	3.74	3.74	Ice																	
	9/17/92	(Minimum Balance)												3.44					0.00		0.00	
	10/01/92	(Hydrologic year begins)												3.44	0.00				0.02		0.02	0.00
M8	2/11/93	6.32			Snow		2.50	2.50	0.08	12	3.82	3.82	0.90	3.44	0.00	2.50	0.39	E	0.98		0.98	0.96
M10	2/16/93	6.85	6.84	6.83	Snow							3.82	0.90	3.44	0.00	3.01	0.41	m	1.23		1.23	1.21
						McCall-tube core to depth of 2.51 m; density, 0.444 kg/L.																
M15	5/15/93		8.00	7.91	Snow							3.82	0.90	3.44	0.00	4.09	0.50	E	2.05		2.05	2.03
M30	9/10/93	2.28			Ice								0.90	2.05	-1.39						-1.39	-1.41
		STAKE 93-B (installed 5/15/93)																				
	9/17/92	(Minimum balance)												4.47					0.00		0.00	
	10/01/92	(Hydrologic year begins)												4.47	0.00				0.02		0.02	0.00
M15	5/15/93	9.19	9.20	9.20	Snow							4.97	0.90	4.47	0.00	4.22	0.50	E	2.11		2.11	2.09
M19	5/17/93	9.05			Snow		5.38	5.38	0.12	4		4.97	0.90	0.00	0.00	4.08	0.51	E	2.08		2.08	2.06
						Probe indicates snow depth is 1.44 m greater here than at stake 91-B; probe rod probably assembled incorrectly.																
						Summer surface height estimated assuming the ice melt at the two stakes was equal.																
						Ice balance continued from stake 91-B.																
M30	9/10/93	3.43	3.43	3.43	Ice								0.90	3.09	-1.39						-1.39	-1.41
	10/01/93	(Hydrologic year ends)												3.00	-1.48				0.00		-1.48	-1.50
	10/10/93	(Minimum balance)												2.92					0.00		-1.56	
M7	2/05/94	5.92	5.91	5.90	Snow		2.66	2.66	0.01	6	3.24	3.24	0.90	2.92		2.66	0.43	E	1.14			

Table 3. Mass balance data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Snow *b(s)*	NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1994 MEASUREMENT YEAR																						
		STAKE 93-B (installed 5/15/93)																				
M30	9/10/93	3.43	3.43	3.43	Ice																	
	10/01/93	(Hydrologic year begins)												3.00	0.00				0.00			0.00
	10/10/93	(Minimum balance)												2.92	-0.08				0.00		0.00	-0.08
M7	2/05/94	5.92	5.91	5.90	Snow		2.66	2.66	0.01	6	3.24	3.24	0.90	2.92	-0.08	2.66	0.43	E	1.14		1.14	1.06
M13	5/13/94		6.98	6.95	Snow							3.24	0.90	2.92	-0.08	3.71	0.43	m	1.60		1.60	1.52
		McCall-tube core to depth of 2.54 m; density, 0.39 kg/L.																				
M29	9/10/94	1.95	1.95	1.95	Ice								0.90	1.76	-1.24						-1.16	-1.24
	9/16/94	(Minimum balance)												1.50	-1.50				0.00		-1.42	-1.50
	10/01/94	(Hydrologic year ends)													-1.50				0.11			-1.39
M5	1/31/95		4.92	4.92	Snow	3.26	3.25	3.25	0.02	11	1.67	1.67	0.90	1.50		3.25	0.381	M	1.24			
M11	5/14/95	6.00	6.01	5.95	Snow							1.67	0.90	1.50		4.28	0.55	m	2.35			
		McCall-tube core to depth of 2.51 m; density, 0.525 kg/L.																				
		STAKE 94-B (installed 5/13/94)																				
		Ice balance continued from stake 93-B.																				
M13	5/13/94	11.17	11.17	11.17	Snow			3.71		1	7.46	7.46	0.90	6.71	-0.08	3.71	0.43	m	1.60		1.60	1.52
		Snow depth measured at stake 93-B.																				
M29	9/10/94	6.15	6.14	6.13	Ice								0.90	5.52	-1.27						-1.19	-1.27
	9/16/94	(Minimum balance)												5.45	-1.34				0.00		-1.26	-1.34
	10/01/94	(Hydrologic year ends)													-1.34				0.11			-1.23
M5	1/31/95		9.34	9.31	Snow	3.26	3.25	3.25	0.02	11	6.06	6.06	0.90	5.45		3.25	0.381	M	1.24			
																				Average of 2 stakes:	-1.34	-1.31
1995 MEASUREMENT YEAR																						
		STAKE 94-B (installed 5/13/94)																				
M29	9/10/94	6.14	6.14	6.13	Ice																	
	9/16/94	(Minimum balance)												5.45					0.00		0.00	
	10/01/94	(Hydrologic year begins)												5.45	0.00				0.11		0.11	0.00
M5	1/31/95		9.34	9.31	Snow	3.26	3.25	3.25	0.02	11	6.06	6.06	0.90	5.45	0.00	3.25	0.381	M	1.24		1.24	1.13
M11	5/14/95	10.40	10.40	10.24	Snow							6.06	0.90	5.45	0.00	4.18	0.55	m	2.30		2.30	2.19
		McCall-tube core to depth of 2.51 m; density, 0.525 kg/L.																				
M30	9/15/95	5.08	5.07	5.07	Ice								0.90	4.56	-0.89							
	9/27/95	(Minimum balance)												4.11	-1.34				0.00		-1.34	-1.45
	10/01/95	(Hydrologic year ends)												4.11	-1.34				0.05			-1.40
T2, BK5	1/12/96	6.59	6.62	6.61	Snow		2.04	2.04	0.04	14	4.57	4.57	0.90	4.11	-1.34	2.04	0.39	m	0.80			
		McCall-tube core to depth of 1.82 m; density, 0.385 kg/L; 3 samples.																				

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska

[Field Notes, locator for observation notebook entries; abbreviation methods are explained in the Mass balance data section. Stake reading, *b',* average height of the surface above a stake base within 3- to 5-m radius, measured by pocket tape; *b**, average surface height on a stake measured by surveying; *b***, average height on a leaning stake calculated (beginning in 1979) as the vertical distance between the stake base and the sloping glacier surface above it, and is the most accurate stake reading. *Stratum*, mass balance stratigraphic unit; Sice, superimposed ice; OFirn, old firn; SFirn, superimposed ice in old firn; NFirn, new firn. Snow Depth, *d*, measured vertically in pits and core holes and by probing. Average depth, *d*; standard error, *s.e.*; and number of observations, *n*, calculated from the pit, core, and probe data. Measured summer surface height between stratigraphic units, Obsvd. *b'ss*, is each stake reading minus the average snow or new firn depth at a pit or core hole measured at the same time. Average summer surface height at the stake, Average *b'ss*, is the average of the measured summer surfaces each season weighted by the number of measurements each observation. Old Firn and Ice Density, ρ, is estimated unless noted as measured. The water equivalent depth of old firn and ice above the stake base, *b'(i)*, is used to calculate the old firn and ice loss, $b_a(i)$, since the beginning of the hydrologic year. Snow and New Firn Depth, *d*, listed under Surface Mass Balance, is the difference between the most accurate stake reading, *b', b**, or *b***, and the average summer surface height at the stake, Average *b'ss*. Snow and New Firn density, ρ, is measured, M; partially measured, m; or estimated, E; see Mass balance data section for methods. Surface Mass Balance Yearly Results, *b(i)*, old firn and ice balance after October 1; *b(s)*, snow balance; *b(f)*, either net or annual new firn balance; b_n, yearly net balance; and b_a, anual balance, are derived from the measurements and explained in the End-of-year estimates section and by Mayo and others, 1972. Measurement units are m/d/y, month/day/year, yr, year; m, meters; kg/L, kilograms per liter; m(w), meters water equivalant; °C, degrees Celsius; km, kilometers; g, grams; m^2, square meters; mm, millimeters; ----, no data available]

<----------OBSERVATIONS---------->												<----------SURFACE MASS BALANCE---------->								
		<---------Stake Readings--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice-->			<------Snow and New Firn------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1966 MEASUREMENT YEAR																						
		No stake at site C the first year.																				
		(Minimum balance) Date unknown; no weather data at the glacier.																	0.00		0.00	
	10/01/65	(Hydrologic year begins) Initial balance conditions for fixed-date year not known, no weather data at the glacier.																			----	0.00
M48D	4/23/66				Snow	4.58	4.58	0.12	5				4.58	0.45	E	2.06			2.06		----	
		Measurement is 1.5 km northeast of site C.																				
		(Minimum balance) Date unknown; no weather data at the glacier.																	0.61	0.58	0.58	----
																			Difference of 0.03 m is water.			
	10/01/66	(Hydrologic year ends) Final balance conditions for fixed-date year unknown; no weather data at the glacier.																		0.58		----
M163C	10/24/66				Snow	1.40	1.40		1				1.40	0.33	E	0.46						
					NFirn	1.10	1.10		1				1.10	0.55	E	0.61			0.58			
		Measurement is 0.5 km west of site C.																				

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<----------OBSERVATIONS---------->												<----------SURFACE MASS BALANCE---------->								
		<---------Stake Readings--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice-->			<------Snow and New Firn------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1967 MEASUREMENT YEAR																						
		STAKE 67-21 (installed 4/02/67 in a snow pit with the stake base on a board at *b'ss*)																				
		(Minimum balance) Date unknown; no weather data at the glacier.																			0.00	
	10/01/66	(Hydrologic year begins) Initial balance conditions not known.																			----	0.00
M13A	4/02/67	4.38			Snow	4.38		4.38		1	0.00					4.38	0.446	M	1.95		1.95	----
	9/15-21/67	Storms prevented access above 1,100 meters altitude.																				
PP715-B	9/17/67	(Minimum balance) Estimate at measurement site from mass balance map (Tangborn and others, 1977).																			-1.00	----
	10/01/67	(Hydrologic year ends)																	0.38			----
M5C	1/30/68	Stake not found.																				
0.00																						
1968 MEASUREMENT YEAR																						
(installed 1/30/68, no wood plug in stake; stake sank during the year)																						
	9/17/67	(Minimum balance)																	0.00		0.00	
	10/01/67	(Hydrologic year begins)																	0.38		0.38	0.00
M5C	1/30/68	3.05			Snow	3.04	3.00	3.02	0.02	2	0.03	0.03				3.02	0.428	M	1.29		1.29	0.91
M7F	3/30/68	4.70			Snow							0.08				4.62	0.43	E	1.99		1.99	1.61
M27D	4/10/68	4.95			Snow		4.85	4.85		1	0.10	0.10				4.85	0.43	E	2.09		2.09	1.71
M64B	6/06/68	4.67			Snow	Very wet snow.						0.30				4.37	0.54	E	2.36		2.36	1.98
M81A	7/19/68	3.64			Snow	3.00		3.00		1	0.64	0.64				3.00	0.560	M	1.68		1.68	1.30
M89C	8/22/68	2.60			Snow	1.21		1.21		1	1.39	1.39				1.21	0.536	M	0.65		0.65	0.27
												Rise of the summer surface on the stake indicates that the stake sank into the underlying old firn.										
	9/18/68	(Minimum balance)																	0.48	0.45	0.45	0.07
	9/30/68	(Hydrologic year ends)																	0.19	0.45		0.26
M110C	10/10/68	----			Snow	0.91		0.91		1						0.91	0.326	M	0.30			
					NFirn	1.04	0.80	0.92	0.12	2						0.92	0.519	M	0.48	0.45		

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1969 MEASUREMENT YEAR											
		STAKE 69-22A (installed 10/10/68; board at base of stake)																				
	9/18/68	(Minimum balance)																	0.00		0.00	
	10/01/68	(Hydrologic year begins)																	0.19		0.19	0.00
M110C	10/10/68	0.91			Snow	0.91		0.91		1	0.00	-0.13				1.04	0.326	M	0.34		0.34	0.15
M114B	10/14/68	0.82			Snow							-0.13				0.95	0.33	E	0.31		0.31	0.12
M1A	1/25/69	2.35			Snow							-0.13				2.48	0.38	E	0.94		0.94	0.75
M2A	1/26/69	2.35			Snow	2.40		2.40		1	-0.05	-0.13				2.48	0.410	M	1.02		1.02	0.83
						Dirt at the 1968 summer surface.																
M22G	4/18/69	5.35			Snow		5.45	5.45		1	-0.10	-0.13				5.48	0.46	E	2.52		2.52	2.33
M65A	6/03/69	5.26			Snow	5.78		5.78		1	-0.52	-0.13				5.39	0.518	M	2.79		2.79	2.60
						Deepest snow pit at Wolverine Glacier.																
						Snow colder than 0°C except at the surface. Cache of 4/20/69 at depth of 1.1 m.																
M78A	7/30/69	2.25			Snow							-0.13				2.38	0.56	E	1.33		1.33	1.14
M79A	7/31/69				Snow	2.20		2.20		1		-0.13				0.13	0.560	M	0.07		0.07	-0.12
	9/7-26/69	(Minimum balance)			(Snow accumulation and ablation approximately equal during this period.)														0.00	1.03	1.03	0.84
M100D	9/13/69	1.90		New	Snow	0.30	0.35	0.34	0.02	6	1.56	1.62				0.28	0.430	M	0.12			1.15
					NFirn	1.60		1.60		1	0.00	-0.13				1.75	0.614	M	1.07	1.03		
																			Difference of 0.04 m is water.			
	9/30/69	(Hydrologic year ends)																	0.02	1.03		0.86
M109C	11/19/69	4.48			Snow	2.62		2.62		1	1.86	1.62				2.86	0.422	M	1.21			
M112	11/22/69	4.57			Snow	2.85		2.85		1	1.72	1.62				2.95	0.42	E	1.24			
						Summer surface dirt visible in the core sample; no snow density measurement.																

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<----------OBSERVATIONS---------->												<----------SURFACE MASS BALANCE---------->								
		<---------Stake Readings--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice-->			<------Snow and New Firn------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1970 MEASUREMENT YEAR																						
		STAKE 70-22A (installed 11/22/69; plywood base on 1969 summer surface; no label)																				
	9/26/69	(Minimum balance)																	0.00		0.00	
	10/01/69	(Hydrologic year begins)																	0.02		0.02	0.00
M109C	11/19/69				Snow	2.62		2.62		1						2.62	0.422	M	1.11		1.11	1.09
M111D	11/22/69	2.85			Snow	2.85		2.85		1	0.00	0.01				2.84	0.42	E	1.19		1.19	1.17
		Summer surface identified in core sample; no snow density measurement.																				
		0.20 m additional snow since 11/19/69.																				
M25E,Z10	4/19/70	Stake buried.			Snow	8.48	8.60	8.54	0.06	2						8.54	0.472	M	4.03		4.03	4.01
		Steam drill through ice layer at depth of 5.5 m to complete the probe measurement.																				
	9/18/70	(Minimum balance)																	2.98	2.85	2.85	2.83
																			Difference of 0.13 m is water.			
M77B	9/29/70	5.40			Snow	0.28	0.28	0.28	0.00	2	5.12	5.12				0.28	0.291	M	0.08			2.83
					NFirn	5.11		5.11		1	0.01					5.11	0.584	M	2.98	2.85		
		Core to depth of 5.27 m in the firn; density increases from 0.61 to 0.64 kg/L at depth of 5.11 m.																				
	9/30/70	(Hydrologic year ends)																	0.08	2.85		2.91
		STAKE 70-22 (installed 4/19/70 on wood base in core hole, missing 0- to 3-m section)																				
	9/26/69	(Minimum balance)																	0.00		0.00	
	10/01/69	(Hydrologic year begins)																	0.02		0.02	0.00
M25E,Z10	4/19/70	11.49			Snow	8.48	8.54	8.52	0.04	3	2.97	3.06				8.43	0.472	M	3.98		3.98	3.96
		Steam drill through ice layer at depth of 5.5 m, then complete the probe.																				
Z16B	6/09/70	10.90			Snow							3.06				7.84	0.50	E	3.92		3.92	3.90
M43D	7/24/70	9.90			Snow	0.20 m new snow last storm.						3.06				6.84	0.56	E	3.83		3.83	3.81
	9/18/70	(Minimum balance)																	2.98	2.85	2.85	2.83
																			Difference of 0.13 m is water.			
M77B	9/29/70	8.71			Snow	0.28	0.23	0.26	0.03	2	8.45	8.45				0.26	0.291	M	0.08			
					NFirn	5.11		5.11			3.34	3.06				5.11	0.584	M	2.98	2.85		
		Core to depth of 5.27 m in the firn; density increases from 0.61 to 0.64 kg/L at depth of 5.11 m.																				
	9/30/70	(Hydrologic year ends)																	0.08	2.85		2.91
																		Average of 2 stakes:			2.85	2.91

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE								
		Stake Readings				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1971 MEASUREMENT YEAR																						
		STAKE 71-22A (installed 1/08/71 in pit with wood base on 1970 summer surface)																				
	9/18/70	(Minimum balance)																	0.00		0.00	
M77B	9/29/70				Snow	0.28	0.23	0.26	0.03	2						0.26	0.291	M	0.08		0.08	
	10/01/70	(Hydrologic year begins)																	0.08		0.08	0.00
M1B	1/08/71	2.70			Snow	2.70		2.70		1	0.00	0.25				2.45	0.361	M	0.88		0.88	0.80
M34H	4/27/71	5.63			Snow		5.55	5.55		1	0.08	0.25				5.38	0.48	E	2.58		2.58	2.50
M38V	5/04/71	5.79			Snow	0.35 m fresh snow.						0.25				5.54	0.50	E	2.77		2.77	2.69
M67A	7/11/71	5.04			Snow	4.50	4.45	4.48	0.03	2	0.56	0.25				4.79	0.598	M	2.86		2.86	2.78
		Stake bent at 4 m.																				
M76E	8/13/71	3.20			Snow		2.93	2.93		1	0.27	0.25				2.95	0.60	E	1.77		1.77	1.69
		(Minimum balance) Date unknown; no weather data at the glacier.																	1.36	1.30	1.30	1.22
																			Difference of 0.06 m is water.			
	9/30/71	(Hydrologic year ends) Final balance conditions not known.																	----	1.30		----
M101A	10/14/71	3.80			Snow							2.48				1.32	0.34	E	0.45			
						Gimballed precipitation gage (1.4 m tall) protruding about 0.2 m above snow.																	
M106H	10/19/71	3.95			Snow	1.59		1.59		1	2.36	2.48				1.47	0.351	M	0.52			
					NFirn	2.37		2.37		1	-0.01					2.37	0.573	M	1.36	1.30		
						Core from bottom of snow pit.						See 1972 measurement year for average *b'ss*.										

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS----->		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---SURFACE MASS BALANCE--->										
		<--Old Firn and Ice-->				<-----Snow and New Firn----->															Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1972 MEASUREMENT YEAR																							
		STAKE 71-22A (installed 1/08/71 in pit with wood base on 1970 summer surface)																					
		(Minimum balance) Date unknown; no weather data at the glacier.																	0.00		0.00	
	10/01/71	(Hydrologic year begins) Initial balance conditions not known.																	----		----	0.00
M101A	10/14/71	3.80			Snow							2.48	0.60	1.49	0.00	1.32	0.34	E	0.45		0.45	----
						Gimballed precipitation gage (1.4 m tall) protruding about 0.2 m above snow.																	
M106H	10/19/71	3.95			Snow	1.59		1.59		1	2.36	2.48	0.60	1.49	0.00	1.47	0.351	M	0.52		0.52	----
						Cored from bottom of snow pit.																	
M108C	10/21/71	4.05			Snow		1.50	1.50		1	2.55	2.48	0.60	1.49	0.00	1.57	0.33	E	0.52		0.52	----
M3C	1/13/72	4.70			Snow	2.15		2.15		1	2.55	2.48	0.60	1.49	0.00	2.22	0.387	M	0.86		0.86	----
						Pit to iced firn, no dirt apparent.																	
M11M	4/10/72	5.26			Snow	2.73	2.85	2.79	0.03	2	2.47	2.48	0.60	1.49	0.00	2.78	0.384	M	1.07		1.07	----
						Dirt at 1971 summer surface.																	
M37A	6/21/72	5.35			Snow							2.48	0.60	1.49	0.00	2.87	0.50	E	1.44		1.44	----
M43B	7/12/72	4.74			Snow							2.48	0.60	1.49	0.00	2.26	0.55	m	1.24		1.24	----
						Pit to ice layer at depth of 1.90 m; density 0.54 kg/L.																	
M60D	8/18/72	2.10			OFirn								0.60	1.26	-0.23						-0.23	----
		STAKE 72-22A (installed in snow near stake 71-22A, 10/21/71)																					
	10/01/71	(Hydrologic year begins) Initial balance conditions not known.																	----		----	0.00
M108C	10/21/71	1.40			Snow		1.50	1.50		1	-0.10	-0.12				1.52	0.33	E	0.50		0.50	----
M3C	1/13/72	2.05			Snow	2.15		2.15		1	-0.10	-0.12				2.17	0.387	M	0.84		0.84	----
M11M	4/10/72	2.65			Snow	2.73	2.85	2.79	0.03	2	-0.14	-0.12				2.77	0.384	M	1.06		1.06	----
M37A	6/21/72	2.72			Snow							-0.12				2.84	0.51	E	1.45		1.45	----
M43B	7/12/72	1.85			Snow							-0.12				1.97	0.54	m	1.06		1.06	----
						Pit to ice layer at depth of 1.90 m; density 0.54 kg/L.																	
M60D	8/18/72	Stake found fallen over; reinstallation on next line.												Old firn balance continued from Stake 71-22A.									
		2.72			OFirn								0.60	1.63	-0.23						-0.23	----
	9/13/72	(Minimum balance)																	0.00		-0.59	----
	9/30/72	(Hydrologic year ends)																	0.01			----
M69H	10/03/72	2.15			Snow		0.03	0.03		1	2.12	2.12	0.60	1.27	-0.59	0.03	0.30	E	0.01			

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field	Date	Tape	Survey			Pit/Core	Probe	Average	s.e.	n	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
													1973 MEASUREMENT YEAR									
		STAKE 73-22A (installed 1/08/73)																				
	9/13/72	(Minimum balance)																	0.00		0.00	
	10/01/72	(Hydrologic year begins)																	0.01		0.01	0.00
M69H	10/03/72				Snow		0.03	0.03		1						0.03	0.30	E	0.01		0.01	0.00
M3B	1/08/73	2.45			Snow	2.50	2.55	2.53	0.03	2	-0.08	-0.04				2.49	0.342	M	0.85		0.85	0.84
M19D	4/17/73	4.95			Snow		4.99	4.99		1	-0.04	-0.04				4.99	0.38	E	1.90		1.90	1.89
M20C	4/18/73				Snow	4.87		4.87		1						4.87	0.376	M	1.83		1.83	1.82
M29E	6/02/73	Stake buried; 6 m long.			Snow																	
M29G	6/03/73				Snow		4.70	4.70		1						4.70	0.51	E	2.40		2.40	2.39
		Probe probably to a false summer surface.																				
T19C	7/06/73	4.75			Snow	4.73		4.73		1	0.02	-0.04				4.79	0.552	M	2.64		2.64	2.63
M52B	8/24/73	2.95			Snow							-0.04				2.99	0.56	E	1.67		1.67	1.66
	9/20/73	(Minimum balance)																	1.54	1.47	1.47	1.46
																			Difference of 0.07 m is water.			
	9/30/73	(Hydrologic year ends)																	0.05	1.47		1.51
M61A	10/16/73	3.82			Snow	1.06	1.09	1.09	0.01	7	2.73	2.73				1.09	0.325	M	0.35			
					NFirn	2.75		2.75		1	-0.02	-0.04				2.75	0.561	M	1.54	1.47		
													1974 MEASUREMENT YEAR									
		STAKE 73-22A (installed 1/08/73)																				
	9/20/73	(Minimum balance)																	0.00		0.00	
	10/01/73	(Hydrologic year begins)																	0.05		0.05	0.00
M61A	10/16/73	3.82			Snow	1.06	1.09	1.09	0.01	7	2.73	2.73				1.09	0.325	M	0.35		0.35	0.30
M62A	10/21/73	4.25			Snow							2.73				1.52	0.34	E	0.52		0.52	0.47
M4C	3/05/74	6.90			Snow	3.41		3.41		1		2.73				4.17	0.372	M	1.55		1.55	1.50
		Pit did not reach 1973 summer surface.																				
T42C	8/04/74	5.19			Snow							2.73				2.46	0.55	E	1.35		1.35	1.30
T46C	9/21/74	3.38			Snow							2.73				0.65	0.55	E	0.36	0.34	0.34	0.29
																			Difference of 0.02 m is water.			
	9/25/74	(Minimum balance)																	0.33	0.32	0.32	0.27
	9/30/74	(Hydrologic year ends)																	0.14	0.32		0.41
		STAKE 74-C (installed 3/12/74)				NOTE: Site C established at new location on longitudinal center line, 3/12/74.																
M8D	3/12/74	3.40			Snow							0.26				3.14	0.41	E	1.29		1.29	1.24
M23B	6/08/74	3.76			Snow	3.50		3.50		1	0.26	0.26				3.50	0.508	M	1.78		1.78	1.73
		Wet snow overlies dry snow in bottom 0.9 m of the snowpack.																				
T42C	8/04/74	1.60			Snow							0.26				1.34	0.55	E	0.74		0.74	0.69
T46B	9/21/74	Stake found fallen over.																				

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----													<-----SURFACE MASS BALANCE-----								
		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice-->			<---Snow and New Firn--->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1975 MEASUREMENT YEAR																						
		STAKE 75-C (installed 2/06/75)																				
	9/25/74	(Minimum balance)																	0.00		0.00	
	10/01/74	(Hydrologic year begins)																	0.14		0.14	0.00
T3A	2/06/75	6.38			Snow	3.35		3.35		1	3.03	3.03				3.35	0.413	M	1.38		1.38	1.24
M10C	6/03/75	8.45			Snow							3.10				5.35	0.51	E	2.73		2.73	2.59
M22C	8/19/75	5.35			Snow	2.18		2.18		1	3.17	3.17				2.18	0.587	M	1.28		1.28	1.14
						Dirty 1974 summer surface observed in the snow pit.																
						Masonite board placed on snow surface at stake.																
T34A	8/21/75	5.21			Snow							3.17				2.04	0.57	E	1.16		1.16	1.02
	9/26/75	(Minimum balance)																	1.01	0.97	0.97	0.83
																			Difference of 0.04 m is water.			
	9/30/75	(Hydrologic year ends)																	0.21	0.97		1.04
T51A	10/27/75	6.00			Snow	0.95		0.95		1	5.05	5.09				0.91	0.389	M	0.35			
		4.95	e observed at the stake.							1	4.95	5.09										
											See 1976 measurement year for average *b'ss*.											
T52B	10/28/75				NFirn	1.66		1.66		1	3.39	3.39				1.70	0.594	M	1.01	0.97		
						Pit in 1975 firn to very dirty 1974 summer surface.							Stake sank 0.36 m during the summer.									
1976 MEASUREMENT YEAR																						
		STAKE 75-C (installed 2/06/75) Masonite board placed on surface 8/19/75.																				
	9/26/75	(Minimum balance)																	0.00		0.00	
	10/01/75	(Hydrologic year begins)																	0.21		0.21	0.00
T51A	10/27/75	6.00			Snow	0.95		0.95		1	5.05	5.09				0.91	0.389	M	0.35		0.35	0.14
		4.95	e observed at the stake.							1	4.95											
	1/23/76	Augustine volcano began erupting; ashfall on Wolverine Glacier.																				
T4B	2/23/76	8.08			Snow	2.90		2.90		1	5.18	5.09				2.99	0.381	M	1.14		1.14	0.93
						Augustine volcanic ash mix with snow 0.49- to 0.66-m depth.																
M9	2/25/76	8.19			Snow		3.08	3.08	0.02	9	5.11	5.09				3.10	0.38	E	1.18		1.18	0.97
M32A	7/12/76	Augustine volcanic ash collected from a 0.25-m^2 area of snow; weight after drying is 9.9 g. That is equivalent to 700 metric tons on Wolverine Glacier.																				
M32B	7/13/76	7.68			Snow	2.72		2.72		1	4.96	5.09				2.59	0.581	M	1.50		1.50	1.29
						Volcanic ash mixed with wet snow at depth of 0.74 to 0.82 m.																
	9/06/76	(Minimum balance)																	0.18	0.17	0.17	-0.04
																			Difference of 0.01 m is water.			
	9/30/76	(Hydrologic year ends)																	0.50	0.17		0.46
T35A	10/20/76	7.37			Snow	1.84		1.84		1	5.53	5.09				2.28	0.365	M	0.83			
						Augustine volcanic ash (Jan. 1976) marks 1976 summer surface at depth of 1.84 m; faintly dirty 1975 summer surface at depth of 2.16 m.																
					NFirn	0.32		0.32		1						0.32	0.548	M	0.18	0.17		
						Masonite board (1975 summer surface) found melted in to depth of 2.23 m.																
						Pit to depth of 3.40 m.																

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b′*	Survey *b**	Survey *b***	*Stratum*	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b′ss*	Summer Surface Average *b′ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b′(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1977 MEASUREMENT YEAR																						
		STAKE 77-C (installed 2/25/77 at original site C)																				
	9/06/76	(Minimum balance)																	0.00		0.00	
	10/01/76	(Hydrologic year begins)																	0.50		0.50	0.00
T35A	10/20/76	----			Snow	1.84		1.84		1						1.84	0.365	M	0.67		0.67	0.17
	Augustine volcanic ash (Jan. 1976) marks 1976 summer surface at depth of 1.84 m.																					
M8A,T4B	2/25/77	4.63			Snow							-4.25				8.88	0.45	E	4.00		4.00	3.50
M32A	6/07/77	4.82			Snow							-4.25				9.07	0.536	m	4.86		4.86	4.36
T32A	6/08/77	4.76			Snow							-4.25				9.01	0.536	M	4.83		4.83	4.33
	Core to depth of 12.5 m. Coarse grained with ice layers below 8.0 m; volcanic ash on auger flights at depth of 11.7 to 12.0 m. Snow and firn density measurements to depth of 12.5 m. Average density to depth of 9.01 m is 0.536 kg/L.																					
M36A,37A	6/11/77	4.65			Snow	8.90		8.90		1	-4.25	-4.25				8.90	0.536	m	4.77		4.77	4.27
	Continued coring the hole of 6/08/77; no volcanic ash layer found. Pit to depth of 1.30 m; density 0.533 kg/L. Core at new location. Dark layer of volcanic ash at depth of 8.90 m.																					
	STAKE 77-C2 (installed 6/07/77, 100 m east of initial site C)																					
M32A	6/07/77	10.39			Snow							1.30				9.09	0.536	E	4.87		4.87	4.37
T32A	6/08/77	10.27			Snow							1.30				8.97	0.536	M	4.81		4.81	4.31
M36A,37A and T35	6/11/77	10.20			Snow			8.90			1.30	1.30				8.90	0.536	m	4.77		4.77	4.27
	Assume snow depth and density are the same as at Stake 77-C. Pit to depth of 1.30 m; density 0.533 kg/L.																					
	9/26/77	(Minimum balance)																	3.43	3.38	3.38	2.88
																			Difference of 0.05 m is water.			
	9/30/77	(Hydrologic year ends)																	0.08	3.38		2.96
M82A,83A	10/24/77	8.90	8.80		Snow		2.82	2.82		1	5.98	5.81				2.99	0.26	E	0.78			
	b′ measured earlier in day than *b**; soft new snow compacting. See 1978 measurement year for average *b′ss*.																					
					NFirn							1.30				4.51	0.76	m	3.43	3.38		
	Core to depth of 3.02 m in hard, frozen, new firn; average density, 0.763 kg/L; density 0.80 kg/L at top; 0.63 kg/L at depth of 3 m.																					
M84	10/25/77				Snow	2.50		2.50		1						2.50	0.308	M	0.77			
	1977 summer surface is at the top of coarse-grained, dense, frozen, new firn.																					

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS----->		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice-->			<---Snow and New Firn--->			<---Yearly Results--->	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b′*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1978 MEASUREMENT YEAR																						
		STAKE 77-C2 (installed 6/07/77, 100 m east of initial site C)																				
	9/26/77	(Minimum balance)																	0.00		0.00	
	10/01/77	(Hydrologic year begins)																	0.08		0.08	0.00
M82A,83A	10/24/77	8.90	8.80		Snow		2.82	2.82		1	5.98	5.81				2.99	0.26	E	0.78			
		b′ measured earlier in day than *b**; soft new snow compacting.																				
M84	10/25/77	----			Snow	2.50		2.50		1						2.50	0.308	M	0.77			
		1977 summer surface is at the top of coarse-grained, dense, frozen, new firn.																				
T3B	2/28/78	12.29			Snow		6.51	6.51	0.05	6	5.78	5.81				6.48	0.45	E	2.92		2.92	2.84
	----	(Minimum balance) Date not known; no weather data at the glacier.																	2.06	1.97	1.97	1.89
																			Difference of 0.09 m is water.			
M113	9/29/78	9.57			Snow	0.15		0.15		1	9.42	9.42				0.15	0.390	M	0.06			1.95
					NFirn							5.81				3.61	0.57	E	2.06	1.97		
	9/30/78	(Hydrologic year ends)																	0.04	1.97		1.93
		STAKE 78-1.8C (installed 2/28/78 at new site C, on longitudinal profile line 200 m east of initial site C)																				
	9/26/77	(Minimum balance)																	0.00		0.00	
	10/01/77	(Hydrologic year begins)																	0.08		0.08	0.00
T3A	2/28/78	9.76			Snow		6.51	6.51	0.05	6	3.25	3.25				6.51	0.45	E	2.93		2.93	2.85
T6A	3/01/78	9.68			Snow							3.25				6.43	0.45	E	2.89		2.89	2.81
						Pit to 2-m depth.																
T30B	6/02/78	11.01			Snow							3.25				7.76	0.51	E	3.96		3.96	3.88
	----	(Minimum balance) Date not known; no weather data at the glacier.																	2.21	2.11	2.11	2.03
																			Difference of 0.10 m is water.			
M113A	9/29/78	7.28			Snow	0.15		0.15		1	7.13	7.13				0.15	0.390	M	0.06			2.09
		No dirt at the 1978 summer surface, only a grain-size increase.																				
					NFirn							3.25				3.88	0.57	E	2.21	2.11		
	9/30/78	(Hydrologic year ends)																	0.05	2.11		2.08
T114	10/01/78	7.26			Snow							7.13				0.13	0.39	E	0.05			
																			Average of 2 stakes:		2.04	2.01

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice-->			<---SURFACE MASS BALANCE--->						
			Survey			Pit/Core	Probe	Average								<---Snow and New Firn--->					Yearly Results	
Field	Date	Tape														Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*	*s.e.*	*n*	*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1979 MEASUREMENT YEAR																						
		STAKE 78-1.8C (installed 2/28/78)																				
		(Minimum balance) Date not known. Insufficient weather data at the glacier.																	0.00		0.00	
	10/01/78	(Hydrologic year begins)																	0.05		0.05	0.00
T114	10/01/78	7.26			Snow							7.13				0.13	0.39	E	0.05		0.05	0.00
M2	3/07/79	11.33			Snow							7.13				4.20	0.44	E	1.85		1.85	1.80
T48	8/04/79	9.46			Snow							7.13				2.33	0.55	E	1.28		1.28	1.23
		STAKE 79-1.8C (installed 3/07/79)																				
		(Minimum balance) Date not known. Insufficient weather data at the glacier.																	0.00		0.00	
	10/01/78	(Hydrologic year begins)																	0.05		0.05	0.00
M2	3/07/79	7.31			Snow			4.20			3.11	3.14				4.17	0.44	E	1.83		1.83	1.78
		Depth from Stake 77-C2.																				
M3	3/11/79	7.63			Snow							3.14				4.49	0.44	E	1.98		1.98	1.93
		Coring auger container left on 3/07/79 buried under fresh snow.																				
T46	8/04/79	5.50			Snow			2.33			3.17	3.14				2.36	0.55	E	1.30		1.30	1.25
		Depth from Stake 77-C2.																				
	9/23/79	(Minimum balance)																		----	----	----
	9/30/79	(Hydrologic year ends)																	0.45	----		----
M4	1/12/80	Stake buried.			Snow	4.88		4.88	0.04	4		3.14				4.88	0.40	E	1.95			
		Snow pit dug at expected stake location; 9-m-long stake not found.																				

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
											1980 MEASUREMENT YEAR											
		STAKE 80-1.8C (installed 1/11/80; length, 9.0 m)																				
	9/23/79	(Minimum balance)																	0.00		0.00	
	10/01/79	(Hydrologic year begins)																	0.45		0.45	0.00
M3B	1/11/80	6.50			Snow		4.88	4.88	0.04	4	1.62	1.62				4.88	0.40	m	1.95		1.95	1.50
														Pit to depth of 2.00 m; density 0.355 kg/L.								
M41	6/06/80	Stake buried.			Snow		Probe not possible by probing; too deep for reliable measurement.														----	----
M88	9/05/80	Stake buried.			Snow		Snow frozen; cannot probe.														----	----
	9/30/80	(Minimum balance and hydrologic year ends)																			----	----
T7	1/26/81	Stake buried.			Snow		Probe snow to hard layers at depths of 6.7 and 10.3 m.									Pit to depth of 3.00 m; density 0.329 kg/L.						
T8	1/27/81	Stake buried.			Snow	12.00		12.00		1						12.00	0.55	m	6.60			
						Core to depth of 13.0 m; grain size increases from 0.5- to 1.5-mm diameter at depth of 12.0 m.											Density at depth of 6.0 m is 0.56 kg/L.					
		STAKE 80-C2 (installed 6/06/80)																				
M41	6/06/80	5.00			ent by probing is not possible; too deep for reliable measurement.																----	----
M61	7/30/80	2.72			Snow																----	----
M84	9/03/80	1.79			Snow	Snow frozen; cannot probe.															----	----
M88	9/05/80	1.74			Snow																----	----
						Sawdust spread on the snow surface 5 m up-glacier from the stake.																
	9/30/80	(Hydrologic year ends and minimum balance)																	0.00		----	----
T7	1/26/81	Stake buried.			Snow		Probe snow to hard layers at depths of 6.7 and 10.3 m.									Pit to depth of 3.0 m; density 0.329 kg/L.						
T8	1/27/81	Stake buried.			Snow	12.00		12.00		1						12.00	0.55	m	6.60			
						Core to depth of 13.0 m; grain size increases from 0.5- to 1.5-mm diameter at depth of 12.0 m.											Density at depth of 6.0 m is 0.56 kg/L.					

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Tape b'	Survey b^*	Survey b^{**}	Stratum	Pit/Core d	Probe d	Average d	s.e.	n	Summer Surface Obsvd. b'_{ss}	Summer Surface Average b'_{ss}	Old Firn and Ice: Density ρ	Old Firn and Ice: Stake $b'(i)$	Old Firn and Ice: Ice $b(i)$	Snow and New Firn: Depth d	Snow and New Firn: Density ρ		Yearly Results: Snow $b(s)$	Yearly Results: NFirn $b(f)$	Yearly Results: Net b_n	Yearly Results: Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1981 MEASUREMENT YEAR																						
		STAKE 81-C (installed 1/26/81) Stake base 6 to 7 m above snowpack base.																				
	10/01/80	(Hydrologic year begins and minimum balance)																	0.00		0.00	0.00
T7	1/26/81	5.00			Snow		6.70			1		-7.05				12.05	0.55	m	6.63		6.63	6.63
							10.34		0.08	2							Pit to 3.00 m; density 0.45 kg/L.					
		Probe to hard layers in the snow; lower layer feels like firn.																				
T8	1/27/81	4.95			Snow	12.00				1	-7.05	-7.05				12.00	0.55	m	6.60		6.60	6.60
		Plywood placed at snow surface. Core to depth of 13.0 m; grain size increases from 0.5- to 1.5-mm diameter at depth of 12.0 m.															Density at depth of 6.0 m is 0.56 kg/L.					
M40	6/04/81	6.86		6.75	Snow							-6.82				13.57	0.57	E	7.73		7.73	7.73
M41	6/05/81	6.84		6.73	Snow	13.55		13.55		1	-6.82	-6.82				13.55	0.57	m	7.72		7.72	7.72
		b^{**} estimated. Core at sawdust site; vegetation and three particles of sawdust found between 13.4- and 13.7-m depth. Pit to 1.20 m; 0.490 kg/L.																				
RM32	9/01/81	3.72	3.73	3.73	Snow							-5.92				9.65	0.600	E	5.79		5.79	5.79
		3.55 t on 6/05/81 melted in 0.17 m below the snow surface.																				
RM34	9/02/81			3.73	Snow	9.65		9.65		1	-5.92	-5.92				9.65	0.600	M	5.79		5.79	5.79
		b^{**} estimated. Core to depth of 12.65 m; grain size increases at depths of 9.65 m and 10.86 m.																				
	9/11/81	(Minimum balance)																	5.62	5.40	5.40	5.40
																			Difference of 0.22 m is water.			
T104	9/25/81	3.91			Snow							3.56				0.35	0.32	E	0.11			5.51
		Core to 0.09-m-thick ice layer at depth of 5.73 m.																				
	9/30/81	(Hydrologic year ends)																	0.21	5.40		5.61
M13	1/23/82	7.76		7.49	Snow		3.93	3.93	0.06	6	3.56	3.56				3.93	0.42	E	1.65			
					NFirn							-5.80				9.36	0.60	E	5.62	5.40		
		Additional snow compaction of 0.12 m estimated below stake after 9/02/81.																				
		STAKE 81-C2 (installed 6/05/81 on wood base in core hole)																				
M41	6/05/81	13.94			Snow	13.55		13.55		1	0.39	0.48				13.46	0.55	m	7.40		7.40	7.40
RM14		Core at sawdust site; vegetation and three particles of sawdust found between 13.4- and 13.7-m depth. Pit to 1.20 m; 0.4 90 kg/L.																				
RM32	9/01/81	10.43	10.39	10.21	Snow							0.56				9.65	0.600	E	5.79		5.79	5.79
RM34	9/02/81			10.21	Snow	9.65		9.65		1	0.56	0.56				9.65	0.600	M	5.79		5.79	5.79
		b^{**} estimated. Core to depth of 12.65 m; grain size increases at depths of 9.65 m and 10.86 m.																				
	9/11/81	(Minimum balance) Additional 0.28 m snow melt, 0.16 m(w), after 9/02/81 estimated from weather data.																	5.45	5.24	5.24	5.24
																			Difference of 0.21 m is water.			
T104	9/25/81	10.50		10.28	Snow							9.65				0.34	0.32	E	0.11			5.35
		b^{**} estimated. Core to a 0.09-m-thick ice layer at depth of 5.73 m.																				
	9/30/81	(Hydrologic year ends)																	0.21	5.24		5.56
M13	1/23/82	14.03		13.58	Snow		3.93	3.93	0.06	6	9.65	9.65				3.93	0.42	E	1.65			
					NFirn							0.56				9.09	0.60	E	5.45	5.24		
																			Average of 2 stakes:		5.32	5.59

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---SURFACE MASS BALANCE--->								
			<---Old Firn and Ice-->			<---Snow and New Firn--->			Yearly Results												
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	*ρ*	*b'(i)*	*b(i)*	*d*	*ρ*		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1982 MEASUREMENT YEAR																						
		STAKE 81-C (installed 1/26/81) Stake sank relative to the 1981 summer surface because of new firn compaction below the stake base.																			
	9/11/81	(Minimum balance)																	0.00		0.00	
T104	9/25/81	3.91			Snow							3.56				0.35	0.32	E	0.11		0.11	
	10/01/81	(Hydrologic year begins)																	0.21		0.21	0.00
M13	1/23/82	7.76		7.49	Snow		3.93	3.93	0.06	6	3.56	3.56				3.93	0.42	E	1.65		1.65	1.44
M38	6/26/82	8.59			Snow							3.56				5.03	0.53	E	2.67		2.67	2.46
M47	6/28/82	8.50			Snow		3.60	3.60		1		3.56				4.94	0.55	E	2.72		2.72	2.51
		Probe to hard layer interpreted to be an ice layer rather than the plywood; a false summer surface.																				
M105,108	9/01/82	6.28		6.28	Snow		1.95	1.95		1	4.33	3.56				2.72	0.57	E	1.55		1.55	1.34
		Stake found bent at *b'* of 6.35 m, bowed below 6.00 m. Probe to hard layer; a false summer surface again.																				
		STAKE 81-C2 (installed 6/05/81 on wood base in core hole)																				
RM32	9/01/81	10.43	10.39	10.21	Snow																	
	9/11/81	(Minimum balance)																	0.00		0.00	
T104	9/25/81	10.50		10.28	Snow							9.65				0.63	0.32	E	0.20		0.20	
	10/01/81	(Hydrologic year begins)																	0.30		0.30	0.00
M13	1/23/82	14.03		13.58	Snow		3.93	3.93	0.06	6	9.65	9.65				3.93	0.42	E	1.65		1.65	1.35
M104	9/01/82			12.05	Snow							9.65				2.40	0.57	E	1.37		1.37	1.07
		STAKE 82-C (installed 1/23/82 by driving into the snow; no label)																				
	9/11/81	(Minimum balance)																	0.00		0.00	
	10/01/81	(Hydrologic year begins)																	0.25		0.25	0.00
M14	1/23/82	3.70		3.69	Snow		3.93	3.93	0.06	6	-0.24	-0.24				3.93	0.42	E	1.65		1.65	1.40
M38	6/26/82			4.58	Snow							-0.24				4.82	0.60	m	2.89		2.89	2.64
		Pit to depth of 0.90 m; density, 0.541 kg/L.																				
M108	9/01/82			2.29	Snow							-0.24				2.53	0.57	E	1.44		1.44	1.19
M110	9/04/82	2.28			Snow		Plywood placed on the snow surface.					-0.24				2.52	0.57	E	1.44		1.44	1.19
	9/21/82	(Minimum balance)																	1.36	1.30	1.30	1.05
																			Difference of 0.06 m is water.			
	9/30/82	(Hydrologic year ends)																	0.03	1.30		1.08
T54	11/06/82	3.34			Snow		1.19	1.19	0.02	10	2.15	2.15				1.19	0.33	E	0.39			
					NFirn							-0.24				2.39	0.57	E	1.36	1.30		

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1983 MEASUREMENT YEAR																						
		STAKE 82-C (installed 1/23/82 by driving into the snow; no label)																				
M110	9/04/82	2.28			Snow	Plywood placed on the snow surface.																
	9/21/82	(Minimum balance)																	0.00		0.00	
	10/01/82	(Hydrologic year begins)																	0.03		0.03	0.00
T54	11/06/82	3.34			Snow		1.19	1.19	0.02	10	2.15	2.15				1.19	0.33	E	0.39		0.39	0.36
T7	1/14/83	6.31		6.16	Snow							2.67				3.49	0.41	E	1.43		1.43	1.40
		Stake sank because not deep in firn.																				
M27	6/15/83	8.26		8.26	Snow		5.55	5.55	0.00	2	2.71	2.67				5.59	0.56	m	3.13		3.13	3.10
		Pit to depth of 1.20 m; density 0.538 kg/L; probe to plywood at Stake 82-C.																				
M60	9/02/83	4.85			Snow		2.25	2.25		1	2.60	2.67				2.18	0.57	E	1.24	1.18	1.18	1.15
		Probe to plywood.																	Difference of 0.06 m is water.			
	9/13/83	(Minimum balance)			Snow melt, 0.14 m(w), from 9/02 to 9/13 estimated using weather data.														1.10	1.03	1.03	1.00
																			Difference of 0.05 m is water.			
	9/30/83	(Hydrologic year ends)																	0.04	1.03		1.04
		STAKE 83-C (installed 1/14/83)																				
	10/01/82	(Hydrologic year begins)																	0.03		0.03	0.00
T7	1/14/83	4.26		4.26	Snow							1.12				3.14	0.40	E	1.26		1.26	1.23
M27	6/15/83	6.57	6.57	6.57	Snow		5.55	5.55	0.00	2	1.02	1.12				5.45	0.56	m	3.05		3.05	3.02
		Pit to depth of 1.20 m; density 0.538 kg/L; probe to plywood at Stake 82-C.																				
M60	9/02/83	3.57	3.57	3.57	Snow		2.25	2.25		1	1.32	1.12				2.45	0.57	E	1.40		1.40	1.37
		STAKE 83-C2 (installed 6/15/83)																				
M27	6/15/83			9.37	Snow		5.55	5.55	0.00	2	3.82	3.90				5.47	0.56	m	3.06		3.06	3.03
		Pit to depth of 1.20 m; density 0.538 kg/L; probe to plywood at Stake 82-C.																				
M60	9/02/83	6.31	6.31	6.31	Snow		2.25	2.25		1	4.06	3.90				2.41	0.57	E	1.37		1.37	1.34
		Probe to plywood.																				
M63,T74	9/04/83	6.22			Snow/Nfirn		New plywood placed at the surface.					3.90				2.32	0.57	E	1.32	1.26	1.32	1.29
		Sawdust spread 10 m from the stake toward survey monument COBRA.																	Difference of 0.06 m is water.			
	9/14/83	(Minimum balance)			Estimate since 9/04/83 using weather data; 0.12 m(w) snowmelt.														1.20	1.14	1.14	1.11
																			Difference of 0.06 m is water.			
	9/30/83	(Hydrologic year ends)																	0.04	1.14		1.15
M11	1/19/84	10.93	10.94	10.90	Snow	4.29	4.25	4.26	0.03	4	6.64	6.64				4.26	0.414	M	1.76			
		Core to sawdust at the1983 summer surface; probe to plywood; 2 probes to hard layer, probably frozen firn.																				
		Summer surface higher than *b'* of 9/04/83 indicates that stake sank 0.42 m into the firn.																				
		Therefore, minimum balance estimated using snow balance of 9/04/83 and weather data.																				
																			Average of 2 stakes:		1.09	1.10

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE									
		Stake Readings				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1984 MEASUREMENT YEAR																						
		STAKE 83-C2 (installed 6/15/83)																				
T74	9/04/83	6.22			New plywood placed at the surface.																	
		Sawdust spread on the snow surface 10 m from the stake toward survey monument COBRA.																				
	9/22/83	(Minimum balance)																	0.00		0.00	
	10/01/83	(Hydrologic year begins)																	0.04		0.04	0.00
M66	11/14/83	8.85			Snow							6.58				2.27	0.37	E	0.84		0.84	0.80
											Stake sank at least 0.40 m.											
M11	1/19/84	10.93	10.94	10.90	Snow	4.29	4.34	4.32	0.01	2	6.58	6.58				4.32	0.414	M	1.79		1.79	1.75
						Core to sawdust at the1983 summer surface; probe to plywood.																
							4.20	4.20	0.00	2		6.58										
						Probe to hard layer 0.12 m above the sawdust and plywood.																
M19	6/08/84	12.41	12.42	12.39	Snow							6.58				5.81	0.53	m	3.08		3.08	3.04
						Pit to depth of 1.20 m; density 0.510 kg/L.																
M42	8/20/84	9.25		9.23	Snow							6.58				2.65	0.55	E	1.46		1.46	1.42
						Plywood and sawdust put on surface.																
	9/27/84	(Minimum balance)																	1.33	1.27	1.27	1.23
																			Difference of 0.06 m is water.			
	9/30/84	(Hydrologic year ends)																	0.17	1.27		1.40
T68	10/30/84	10.26			Snow							8.92				1.34	0.35	E	0.47			
RM5	1/12/85	12.57		12.53	Snow		3.65	3.65	0.03	4	8.88	8.92				3.61	0.40	E	1.46			
						Probe to plywood.																
					NFirn							6.58				2.34	0.57	E	1.33	1.27		
												See 1985 measurement year for average *b'ss*.										

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Stake Readings: Tape *b'*	Survey *b**	Survey *b***	Stratum	Snow Depth: Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice: Density ρ	Stake *b'(i)*	Ice *b(i)*	Snow and New Firn: Depth *d*	Density ρ		Yearly Results: Snow *b(s)*	NFirn *b(f)*	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1985 MEASUREMENT YEAR																						
		STAKE 83-C2 (installed 6/15/83; plywood and sawdust at 1983 and 1984 summer surfaces)																				
	9/27/84	(Minimum balance)																	0.00		0.00	
	10/01/84	(Hydrologic year begins)																	0.17		0.17	0.00
T68	10/30/84	10.26			Snow							8.92				1.34	0.35	E	0.47		0.47	0.30
RM5	1/12/84	12.57		12.53	Snow		3.65	3.65	0.03	4	8.88	8.92				3.61	0.40	E	1.44		1.44	1.27
RM11	1/13/85	12.53	12.54	12.54	Snow	3.60		3.60		1	8.94	8.92				3.62	0.375	M	1.36		1.36	1.19
M33	6/05/85	Stake buried.			Snow		4.00	4.00	0.03	6						----	----	----	----		----	----
		Pit to 1.20 m depth; density 0.46 kg/L. Probe to a false summer surface. See Stake 85-C.																				
M51	6/14/85	Stake buried.			Snow	6.27		6.27		1						6.27	0.53	m	3.32		3.32	3.15
		Core to 1984 sawdust layer; 0.11 m new snow; no snow density measurements.															Density estimated using 6/5/85 data.					
RM77	8/27/85	12.70	12.70	12.63	Snow			3.66	E			8.92				3.71	0.586	E	2.17		2.17	2.00
RM78	8/28/85			12.53	E Snow	3.51	3.57	3.56	0.02	3	8.97	8.92				3.61	0.586	M	2.12		2.12	1.95
		Core to the sawdust layer and 2 probes to the plywood at Stake 83-C2.																				
	9/17/85	(Minimum balance)			Snowmelt, 0.33 m(w), from 8/28 estimated using the weather data.														1.84	1.77	1.77	1.60
																			Difference of 0.07 m is water.			
	9/30/85	(Hydrologic year ends)																	0.36	1.77		1.96
		STAKE 85-C (installed 6/05/85)																				
	10/01/84	(Hydrologic year begins)																	0.17		0.17	0.00
M35	6/05/85		8.34	8.33	Snow		4.00	4.00	0.03	6		1.94				6.39	0.54	m	3.45		3.45	3.28
		Pit to depth of 1.20 m; density 0.457 kg/L.																				
		Core on 6/14/85 indicates that snow probe data this date are incorrect.																				
M51	6/14/85				Snow	6.27		6.27		1		1.94				6.27	0.54	E	3.39		3.39	3.22
		Core to the sawdust layer; 0.11 m new snow.																				
RM77	8/27/85		5.59	5.60	Snow			3.66	*d* estimated			1.94				3.66	0.586	E	2.14		2.14	1.97
RM78	8/28/85			5.50	E Snow	3.51	3.57	3.56	0.02	3	1.94	1.94				3.56	0.586	M	2.09		2.09	1.92
		Core to the sawdust layer and 2 probes to the plywood at stake 83-C2.																				
		New plywood placed at the surface.																				
	9/17/85	Estimates		4.92	Snow							1.94				2.98	0.59	E	1.76	1.69		
	9/17/85	(Minimum balance)			Snowmelt, 0.33 m(w), from 8/28 estimated using the weather data.														1.76	1.69	1.69	1.52
																			Difference of 0.07 m is water.			
	9/30/85	(Hydrologic year ends)																	0.36	1.69		1.88
M12	2/19/86	11.55	11.56	11.53	Snow		5.75			1	5.78	5.80				5.73	0.44	E	2.52			
		Stake top found by digging a pit at the predicted stake location. Leaning stake bent straight at 9.2 m before the survey.																				
		Probe to plywood. Apparent summer surface rise since 9/17/85 caused by deformation of the bent stake.																				
		See 1986 measurement year for average *b'ss*.																				
																			Average of 2 stakes:		1.73	1.92

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
												1986 MEASUREMENT YEAR										
		STAKE 85-C (installed 6/05/85)																				
	9/16/85	(Minimum balance)				See 1985 measurement year for estimate of the initial balance conditions at the stake.													0.00		0.00	
	9/30/85	(Hydrologic year begins)																	0.36		0.36	0.00
M9	2/18/86				Snow	Core to 7.5 m; grain size increases below depth of 6.7 m; no sawdust layer found.																
M12	2/19/86	11.55	11.56	11.53	Snow		5.75			1	5.78	5.80				5.73	0.44	E	2.52		2.52	2.16
		Stake top found by digging a pit at the predicted stake location. Leaning stake bent straight at 9.2 m before the survey.																				
		Probe to plywood.																				
RM17	6/15/86		11.59	11.59	Snow							5.80				5.79	0.55	m	3.18		3.18	2.82
		Pit to depth of 0.90 m; density 0.529 kg/L; 0.82 m depth to Augustine volcanic ash layer.																				
		Base of fresh snow at depth of 0.85 m; very wet, granular snow below.																				
T54	8/20/86	8.95		8.65	Snow		2.83	2.83	0.02	2	5.82	5.80				2.85	0.57	E	1.62		1.62	1.26
		Probe to hard layer at depth of 2.13 m, and plywood at 2.83 m.																				
		Surface is 60% covered with large melt pits, 0.7-m deep, caused by Augustine volcanic ash; average surface is 0.24 m below the flat upper surface.																				
		STAKE 86-C (installed 2/18/86)																				
		Note: No independent observations of snow depth obtained at this stake; therefore, only the stake readings are listed.																				
M9	2/18/86	3.28	3.27	3.27	Snow																	
RM17	6/15/86	3.42	3.40	3.40	Snow																	
T53	8/20/86	0.40			Snow																	
		STAKE 86-C1 (installed 6/15/86)																				
RM17	6/15/86		8.65	8.66	Snow							2.87				5.79	0.55	E	3.18		3.18	2.82
		Pit to depth of 0.90 m; density 0.529 kg/L; 0.82 m depth to Augustine volcanic ash layer.																				
		Base of fresh snow at depth of 0.85 m; very wet, granular snow below.																				
T54	8/20/86	5.70			Snow		2.83	2.83	0.02	2	2.87	2.87				2.83	0.57	E	1.61		1.61	1.25
		6.12	6.13	6.14	Snow																	
		Surface is 60% covered with melt pits about 0.7 m deep. Probe to hard layer at depth of 2.13 m and plywood at 2.83 m.																				
		First stake reading is an estimate of the average surface height.																				
		Second set of readings are observations at the flat upper surface.																				
	9/20/86	(Minimum balance)				Mass balance estimated from 8/20/86 using weather data.										1.58	0.57	E	0.90	0.86	0.86	0.50
																			Difference of 0.04 m is water.			
	9/30/86	(Hydrologic year ends)																	0.04	0.86		0.54

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

OBSERVATIONS													SURFACE MASS BALANCE								
		Stake Readings				Snow Depth					Summer Surface		Old Firn and Ice			Snow and New Firn				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1987 MEASUREMENT YEAR																						
		STAKE 87-C (installed 6/13/87)																				
	9/20/86	(Minimum balance)																	0.00		0.00	
	10/01/86	(Hydrologic year begins)																	0.04		0.04	0.00
T27	6/12/87	No stakes visible.																				
M31	6/13/87	8.04	8.00	7.81	Snow	8.25		8.25		1	-0.44	-0.44				8.25	0.54	m	4.46		4.46	4.42
		Probe could not be pushed deeper than 6.45 m by two glaciologists.																				
		New snow to depth of 0.85 m; density 0.330 kg/L; overlying granular, wet snow. Density to depth of 1.55 m is 0.361 kg/L.																				
		Coring auger flights retrieved volcanic ash from a depth between 8.2 and 8.5 m, the 1986 summer surface.																				
	9/08/86	(Minimum balance)																	3.14	3.00	3.00	2.96
																			Difference of 0.14 m is water.			
	9/30/87	(Hydrologic year ends)																	0.50	3.00		3.46
RM22	10/01/87	6.52	6.47	6.42	Snow	1.36		1.36		1	5.06	5.06				1.46	0.34	E	0.50			
		5.06			NFirn							-0.44				5.50	0.57	E	3.14	3.00		
		Pit at stake; 1987 *b'ss* observed.				Plywood placed on stake on the 1987 summer surface; sawdust spread on the snow surface.																
M10	3/11/88	Stake buried.			Snow		7.80			1		5.06										
		Steam drilled to the plywood at the predicted location for the buried stake.																				

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----												<-----SURFACE MASS BALANCE-----								
		<---Stake Readings--->				<---Snow Depth--->					Summer Surface	<---Old Firn and Ice-->			<---Snow and New Firn--->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1988 MEASUREMENT YEAR																						
		STAKE 88-C (installed 3/19/88 with wood base in core hole; see field notes for additional labeling information.)																				
	9/08/86	(Minimum balance)																	0.00		0.00	
	10/01/87	(Hydrologic year begins)																	0.50		0.50	0.00
M7	3/18/88	No stakes visible.				Core to 10.25 m without finding the summer surface.																
M9	3/19/88	10.08		10.08	Snow		7.80	7.80		1	2.28	2.25				7.83	0.46	m	3.60		3.60	3.10
		Probe with steam drill to the plywood at the predicted location for buried Stake 87-C; pit to depth of 1.20 m, density 0.296 kg/L.																				
M17	6/10/88	9.89	9.87	9.87	Snow		7.65	7.65	0.00	2	2.24	2.25				7.62	0.51	m	3.89		3.89	3.39
						Probe with steam drill to plywood at the 1987 summer surface at Stake 87-C.																
						Measure snow with McCall tube to depth of 2.36 m; density 0.500 kg/L.																
	9/08/88	(Minimum balance)																	2.60	2.50	2.50	2.00
																			Difference of 0.10 m is water.			
M29.5 and RM14	9/18/88		6.72	6.72	Snow	0.20		0.20		1	6.52	6.52				0.20	0.35	E	0.07	2.50		2.07
		Summer surface at depth of 0.20 m is clean, it has no dirt; new firn has ice layers; the snow does not.																				
		Plywood placed on the snow surface at the stake.																				
					NFirn		4.28	4.28	0.03	2		2.25				4.27	0.61	m	2.60	2.50		
		Probe to plywood 7 m from the stake. Pit to depth of 1.0 m; snow density not measured; density of the new firn 0.601 kg/L.																				
	9/30/88	(Hydrologic year ends)																	0.21	2.50		2.21
	Note: The following experiments were placed at site C on 9/18/88 to measure the depth of very deep snowpacks reliably:																					
	Both plywood and wire mesh on the surface at the stake for probing with a steam drill.																					
	Sawdust put on surface to mark summer surface in core samples of snow and firn.																					
	Radio beacon transmitter with a temperature sensor put on surface for sawdust location and summer surface temperature measurements.																					
	Magnet put on surface for location of stake and summer surface location found using a magnetometer.																					

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape *b'*	Survey *b**	Survey *b***	Stratum	Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface Obsvd. *b'ss*	Summer Surface Average *b'ss*	Old Firn and Ice Density *ρ*	Old Firn and Ice Stake *b'(i)*	Old Firn and Ice Ice *b(i)*	Snow and New Firn Depth *d*	Snow and New Firn Density *ρ*		Yearly Results Snow *b(s)*	Yearly Results NFirn *b(f)*	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1989 MEASUREMENT YEAR																						
STAKE 88-C (installed 3/19/88 with wood base in core hole; see field notes for additional labeling information.)																						
	9/08/88	(Minimum balance)																	0.00			
RM14	9/18/88		6.72	6.72	Snow	0.20		0.20		1	6.52					0.20	0.35	E	0.07			
		Summer surface at depth of 0.20 m is clean, it has no dirt; new firn identified by the presence of its ice layers.																				
		Plywood placed on the snow surface at the stake, 0.20 m above the summer surface.																				
	10/01/88	(Hydrologic year begins)																	0.21		0.21	0.00
T9	2/16/89	10.71	10.69	10.67	Snow		3.42	3.52	0.00	6		6.52				4.15	0.47	m	1.95		1.95	1.74
		Probes to "plywood" probably an ice layer; a false summer surface. Core with McCall tube to depth of 2.36 m; density 0.45 kg/L.																				
		Plywood estimated to be 0.10 m above the summer surface at this time; see 9/18/88.																				
T60	6/17/89	11.27	11.28	11.23	Snow		3.84	3.94	0.01	4		6.52				4.71	0.51	E	2.40		2.40	2.19
		Probes to "plywood" probably an ice layer; a false summer surface.																				
	9/29/89	(Minimum balance)																	0.13	0.13	0.13	-0.08
	9/30/89	(Hydrologic year ends)																	0.01	0.13		0.06
T162	10/08/89	7.47	7.48	7.41	Snow		0.68	0.68	0.01	7	6.73	6.73				0.68	0.31	E	0.21			
		Probes to "plywood" and a very hard firn surface. Plywood in hard, frozen, new firn; not observed directly.																				
					NFirn							6.52				0.21	0.60	E	0.13	0.13		
1990 MEASUREMENT YEAR																						
STAKE 88-C (installed 3/19/88 with wood base in core hole; see field notes for additional labeling information.)																						
T60	6/17/89	11.27	11.28	11.23	Snow		3.84	3.84	0.01	4												
	9/29/89	(Minimum balance)																	0.00		0.00	
	10/01/89	(Hydrologic year begins)												4.04	0.00				0.01		0.01	0.00
T162	10/08/89	7.47	7.48	7.41	Snow		0.68	0.68	0.01	7	6.73	6.73	0.60	4.04	0.00	0.68	0.31	E	0.21		0.21	0.20
		Probes to "plywood" and a very hard firn surface. Plywood in hard, frozen, new firn; not observed directly.																				
M32	9/06/90	5.55			OFirn								0.60	3.33	-0.71						-0.71	-0.72
STAKE 89-C (installed 10/08/89)																						
	9/29/89	(Minimum balance)										5.12							0.00		0.00	
	10/01/89	(Hydrologic year begins)												4.10	0.00				0.01		0.01	0.00
T162	10/08/89	5.80	5.80	5.80	Snow		0.68	0.68	0.01	7	5.12	5.12	0.80	4.10	0.00	0.68	0.31	E	0.21		0.21	0.20
T60	2/14/90	8.63	8.61	8.60	Snow							5.12	0.80	4.10	0.00	3.48	0.41	E	1.43		1.43	1.42
T63	3/17/90	9.30			Snow							5.12	0.80	4.10	0.00	4.18	0.44	E	1.84		1.84	1.83
RM2	6/02/90	8.72	8.71	8.66	Snow							5.12	0.80	4.10	0.00	3.54	0.50	E	1.77		1.77	1.76
M31	9/06/90		4.29	4.28	OFirn								0.80	3.42	-0.68						-0.68	-0.69
M36	9/11/90	4.20			OFirn	wood placed at the firn surface.							0.80	3.36	-0.74						-0.74	-0.75
	9/16/90	(Minimum balance)												3.24	-0.86				0.00		-0.86	-0.87
	9/30/90	(Hydrologic year ends)												3.24	-0.86				0.14			-0.73
M2	1/06/91	6.09	6.08	6.07	Snow	1.93	2.03	2.02	0.04	11	4.05	4.06	0.80	3.24		2.01	0.408	M	0.82			
												See 1991 measurement year for average *b'ss*.										

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field / Notes	Date	Stake Readings: Tape *b'*	Survey *b**	*b***	*Stratum*	Snow Depth: Pit/Core *d*	Probe *d*	Average *d*	*s.e.*	*n*	Summer Surface: Obsvd. *b'ss*	Average *b'ss*	Old Firn and Ice: Density *ρ*	Stake *b'(i)*	Ice *b(i)*	Snow and New Firn: Depth *d*	Density *ρ*		Yearly Results: Snow *b(s)*	NFirn *b(f)*	Net b_n	Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1991 MEASUREMENT YEAR																						
		STAKE 89-C (installed 10/08/89)																				
M36	9/11/90	4.20			OFirn	wood placed at the firn surface.																
	9/16/90	(Minimum balance)																	0.00		0.00	
	10/01/90	(Hydrologic year begins)																	0.14		0.14	0.00
M2	1/06/91	6.08		6.07	Snow	1.93	2.03	2.02	0.04	11	4.05	4.06				2.01	0.408	M	0.82		0.82	0.68
M18	5/13/91	Stake buried.					4.85	4.85	0.05	2		4.06				6.30	0.46	E	2.90		2.90	2.76
		Probe likely did not reach to the summer surface; see note for 5/16/91.																				
M19	5/16/91	Stake buried.										4.06										
		Surface altitude measurement this date and summer surface altitude data for 1/6/91 and 9/18/91 indicate a snow depth of about 6.3 m.																				
M37	9/18/91	5.93	5.93	5.92	Snow		1.75	1.75		1	4.17	4.06				1.86	0.57	E	1.06	1.01	1.01	0.87
		Probe to plywood.																	Difference of 0.05 m is water.			
	9/22/91	(Minimum balance)																	1.03	0.98	0.98	0.84
	9/30/91	(Hydrologic year ends)																	0.39	0.98		1.23
M1	1/22/92	Stake buried.																				
M6	1/25/92	Stake buried.					4.98	4.98		1						4.98	0.43	E	2.14			
		Probe using the steam drill to plywood at the predicted stake location; a reliable depth measurement.																				
		STAKE 91-C (installed 5/16/91)																				
	9/16/90	(Minimum balance)																	0.00		0.00	
	10/01/90	(Hydrologic year begins)																	0.14		0.14	0.00
M19	5/16/91	7.96			Snow		5.15	5.15		1	2.81	1.99				5.97	0.44	m	2.63		2.63	2.49
		Probe depth and calculated summer surface height, *b'ss* , not verified by the measurement of 9/18/91. Probe hit a false summer surface.																				
		McCall snow core to depth of 2.97 m; density, 0.34 kg/L.																				
M37	9/18/91			3.74	Snow			1.75			1.99	1.99				1.75	0.57	E	1.00		1.00	0.86
		Stake reinstalled.				Snow depth from probe to plywood at Stake 89-C.																
		4.78		4.78	Snow			1.75			3.03	3.03				1.75	0.57	E	1.00		1.00	0.86
		Plywood placed at the surface.																				
	9/22/91	(Minimum balance)																	0.97	0.93	0.93	0.79
																			Difference of 0.04 m is water.			
	9/30/91	(Hydrologic year ends)																	0.39	0.93		1.18
																		Average of 2 stakes.			0.96	1.21

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Field Notes	Date	Tape b'	Survey b^*	b^{**}	Stratum	Pit/Core d	Probe d	Average d	s.e.	n	Summer Surface Obsvd. b'_{ss}	Summer Surface Average b'_{ss}	Old Firn and Ice Density ρ	Old Firn and Ice Stake $b'(i)$	Old Firn and Ice Ice $b(i)$	Snow and New Firn Depth d	Snow and New Firn Density ρ		Yearly Results Snow $b(s)$	Yearly Results NFirn $b(f)$	Yearly Results Net b_n	Yearly Results Annual b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1992 MEASUREMENT YEAR																						
		STAKE 91-C (reinstalled 9/18/91). Plywood put at surface.																				
M37	9/18/91	4.78		4.78	Snow			1.75			3.03											
		Snow depth from Stake 89-C.																				
	9/22/91	(Minimum balance)				Estimated 0.05 m melt after 9/18/91, using weather data.							Estimated b'_{ss}.						0.00		0.00	
	10/01/91	(Hydrologic year begins)																	0.39		0.39	0.00
M6	1/25/92	Stake buried.			Snow		4.98	4.98		1		3.03				4.98	0.43	E	2.14		2.14	1.75
		Steam drilled to the plywood at the stake.																				
	9/01/92	(Minimum balance)																	1.31	1.25	1.25	0.86
																			Difference of 0.11 m is water.			
M57	9/03/92	5.35			Snow	0.03		0.03		1	5.32	5.32				0.03	0.30	E	0.01			0.87
					NFirn		1.85	1.85		1		3.03				2.29	0.57	E	1.31	1.25		
		Probe above the plywood; probably hit an ice layer.																				
	9/30/92	(Hydrologic year ends)																	0.06	1.25		0.92
		Stake abandoned.																				
		STAKE 92-C (installed 1/23/92)																				
	9/22/91	(Minimum balance)																	0.00		0.00	
	10/01/91	(Hydrologic year begins)																	0.39		0.39	0.00
M5	1/23/92	5.83		5.83	Snow							0.80				5.03	0.43	E	2.16		2.16	1.77
M6	1/25/92	5.78			Snow		4.98	4.98		1	0.80	0.80				4.98	0.43	E	2.14		2.14	1.75
		Lowering caused by snow compaction.				Snow depth measured at Stake 91-C, steam drilled to plywood.																
M10	5/13/92	7.15	7.14	7.15	Snow							0.80				6.35	0.44	m	2.79		2.79	2.40
M13	5/14/92	McCall snow core to 2.64 m; density 0.42 kg/L.																				
	9/01/92	(Minimum balance)																	1.34	1.28	1.28	0.89
																			Difference of 0.06 m is water.			
M56	9/03/92	3.20	3.19	3.18	Snow	0.03		0.03		1	3.15	3.15				0.03	0.30	E	0.01			0.90
		1992 summer surface identified by grain-size change alone; no dirt visible.																				
		3.15			NFirn							0.80				2.35	0.57	E	1.34	1.28		
M64	9/07/92	3.24			Snow	Plywood placed at the surface.						3.15				0.09	0.30	E	0.03			0.92
	9/30/92	(Hydrologic year ends)																	0.06	1.28		0.95
M4	2/08/93	6.76	6.74	6.72	Snow		3.57	3.57	0.00	2	3.15	3.15				3.57	0.41	E	1.46			
		Probe to plywood; snow depth estimated to be 0.05 m deeper.																				
																			Average of 2 stakes.		1.27	0.94

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<----------OBSERVATIONS----------													<----------SURFACE MASS BALANCE----------								
		<---------Stake Readings--------->				<----------Snow Depth---------->					Summer Surface		<---Old Firn and Ice-->			<------Snow and New Firn------->				Yearly Results	
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1993 MEASUREMENT YEAR																						
		STAKE 92-C (installed 1/23/92)																				
	9/01/92	(Minimum balance)																	0.00		0.00	
M56	9/03/92		3.19	3.18	Snow	0.03		0.03		1	3.15	3.15				0.03	0.30	E	0.01		0.01	
M64	9/07/92	3.24			Snow		Plywood placed at the surface.					3.15				0.09	0.30	E	0.03		0.03	
	9/30/92	(Hydrologic year begins)																	0.06		0.06	0.00
M4	2/08/93	6.76	6.74	6.72	Snow		3.57	3.57	0.00	2	3.15	3.15				3.57	0.41	E	1.46		1.46	1.40
							Probe to plywood; snow depth estimated to be 0.05 m deeper.															
M10	2/16/93	7.40			Snow							3.15				4.25	0.42	E	1.79		1.79	1.73
		Stake bent upright at 7.0 m.																				
M13	5/15/93	10.04	10.02	9.98	Snow							3.15				6.83	0.49	m	3.35		3.35	3.29
							McCall snow sample to 2.65 m; density 0.39 kg/L.															
M36	9/13/93	4.57	4.54	4.53	Snow							3.15				1.38	0.55	E	0.76	0.72	0.76	0.70
							Plywood installed at snow surface.												Difference of 0.04 m is water.			
	9/15/93	(Minimum balance)																	0.71	0.67	0.67	0.61
	9/30/93	(Hydrologic year ends)																	0.27	0.67		0.88
M6	2/05/94	Stake buried.																				
M12	5/13/94	10.48			Snow		5.95	5.95		1	4.53	4.53				5.95	0.50	E	2.98			
		b' calculated from snow depth.					Steam drilled to plywood at the stake.						Summer surface observed 9/13/93.									
1994 MEASUREMENT YEAR																						
		STAKE 94-C2 (installed 2/05/94)																				
	9/15/93	(Minimum balance)																	0.00		0.00	
	10/01/93	(Hydrologic year begins)																	0.27		0.27	0.00
M2	2/04/94	Assumed *b***	6.30		Snow		4.00	4.00		1	2.30	2.36				3.94	0.41	E	1.62		1.62	1.35
M6	2/05/94	6.33	6.30	6.29	Snow							2.36				3.93	0.41	E	1.61		1.61	1.34
M12	5/13/94	8.32	8.33	8.32	Snow		5.95	5.95		1	2.37	2.36				5.96	0.50	E	2.98		2.98	2.71
							Steam drilled to plywood at Stake 92-C.															
M25	9/07/94	4.19	4.18	4.17	Snow		1.75	1.75		1	2.42	2.36				1.81	0.55	E	1.00		1.00	0.73
							Steam drilled to plywood at Stake 92-C.															
							Plywood placed on surface.															
	9/16/94	(Minimum balance)																	1.35	1.29	1.29	1.02
																			Difference of 0.06 m is water.			
	9/30/94	Hydrologic year ends)																	0.23	1.29		1.25
M7	2/01/95	8.90	8.84	8.78	Snow		4.60	4.60		1	4.18	4.18				4.60	0.42	E	1.93			
							Probe to plywood.															
					NFirn							1.82				2.36	0.57	E	1.35	1.29		

Table 4. Mass balance data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

<-----OBSERVATIONS-----													<-----SURFACE MASS BALANCE-----								
		<---Stake Readings--->				<---Snow Depth--->					Summer Surface		<---Old Firn and Ice-->			<---Snow and New Firn--->			Yearly Results		
Field	Date	Tape	Survey			Pit/Core	Probe	Average	*s.e.*	*n*	Obsvd.	Average	Density	Stake	Ice	Depth	Density		Snow	NFirn	Net	Annual
Notes		*b'*	*b**	*b***	*Stratum*	*d*	*d*	*d*			*b'ss*	*b'ss*	ρ	*b'(i)*	*b(i)*	*d*	ρ		*b(s)*	*b(f)*	b_n	b_a
	m/d/y	m	m	m		m	m	m	m		m	m	kg/L	m(w)	m(w)	m	kg/L		m(w)	m(w)	m(w)	m(w)
1995 MEASUREMENT YEAR																						
		STAKE 94-C2 (installed 2/05/94)																				
M25	9/07/94	4.19	4.18	4.17	Snow		1.75	1.75		1												
		Plywood placed on surface.																				
	9/16/94	(Minimum balance)																	0.00		0.00	
	10/01/94	(Hydrologic year begins)																	0.23		0.23	0.00
M4	1/31/95	9-m stake not found.			Snow		4.50	4.50	0.00	2						4.50	0.42	E	1.89		1.89	1.66
M7	2/01/95	8.90	8.84	8.78	Snow		4.60	4.60		1	4.18	4.34				4.44	0.42	E	1.86		1.86	1.63
		Probe to plywood.																				
M10	5/14/95	10.66	10.74	10.69	Snow							4.34				6.35	0.50	E	3.18		3.18	2.95
		McCall snow sample to 2.67 m; density 0.44 kg/L.																				
M28	9/14/95	6.79			Snow		2.42	2.42	0.02	5	4.37	4.34				2.45	0.57	E	1.40		1.40	1.17
		Probe to plywood.																				
	9/26/95	(Minimum balance)																	1.09	1.04	1.04	0.81
																			Difference of 0.05 m is water.			
	10/01/95	(Hydrologic year ends)																	0.11	1.04		0.92
T7	1/13/96	9.25	9.23	9.22	Snow	2.97		2.97		1	6.25	6.25				2.97	0.397	M	1.18			
					NFirn							4.34				1.91	0.57	E	1.09	1.04		

Table 5. Daily and monthly average air temperature at the weather station located at 990 meters altitude in Wolverine Glacier Basin, Alaska, during the 1995 hydrologic year and October 1995, the first month of the 1996 hydrologic year

[Average temperature measured each day starting at midnight Alaska Standard Time from the continuous record of air temperature; data in degrees Celsius]

Day	Oct. 94	Nov. 94	Dec. 94	Jan. 95	Feb. 95	Mar. 95	Apr. 95	May 95	Jun. 95	Jul. 95	Aug. 95	Sep. 95	Oct. 95
1	-1.0	-5.1	-9.4	-2.5	-4.7	-5.9	-0.4	6.9	0.8	4.9	4.5	5.4	1.7
2	0.4	-1.6	-8.0	-2.7	-4.5	-2.5	-1.1	6.0	1.8	8.2	4.6	4.5	3.6
3	4.2	-2.9	-4.5	-0.4	-2.8	2.6	-1.2	1.3	2.1	6.2	5.5	4.9	0.7
4	4.1	-4.8	-2.7	-2.1	-1.7	-0.2	-2.2	1.0	2.5	9.6	7.5	4.4	1.1
5	1.8	-6.2	-11.2	-1.3	-1.4	-3.6	-2.8	-1.7	2.5	11.9	7.4	4.5	-0.5
6	0.9	-5.7	-14.2	-2.9	-4.5	-4.5	-1.1	-2.1	1.0	10.6	6.7	5.2	0.5
7	-0.1	-8.2	-9.5	-3.5	-3.9	-2.9	0.1	-1.0	0.9	5.1	4.8	6.2	0.5
8	0.1	-9.1	-7.7	-3.4	-2.3	-3.7	-1.2	1.5	2.4	8.0	7.1	5.0	2.0
9	-2.4	-5.9	-6.6	-4.0	-3.4	-5.8	-2.2	5.9	6.4	11.7	5.2	4.8	1.4
10	-1.4	-3.5	-5.9	-8.4	-3.1	-11.5	-0.7	4.9	15.6	6.4	6.7	5.2	-2.0
11	-1.0	-6.0	-4.2	-11.9	-0.7	-15.6	1.0	5.8	15.3	7.5	7.2	4.3	-4.0
12	0.8	-9.0	-2.8	-14.0	-3.4	-16.3	-3.2	5.1	11.8	6.5	4.3	4.7	-4.7
13	2.2	-10.0	-4.5	-12.0	-5.5	-19.4	-2.2	0.8	6.8	7.3	4.8	4.6	-4.5
14	0.6	-9.9	-5.9	-13.6	-6.7	-22.3	-2.9	1.9	4.4	5.5	7.5	5.9	-2.8
15	0.0	-6.3	-5.3	-9.7	-10.6	-16.2	-4.4	0.5	2.3	5.0	9.6	6.7	-1.0
16	-0.2	-5.1	-5.6	-5.6	-11.3	-5.9	-3.4	-0.5	5.0	5.9	10.0	8.5	-1.8
17	-5.4	-4.9	-4.7	-4.4	-12.6	-7.6	-1.9	1.0	8.6	7.5	11.8	6.3	-2.2
18	-5.9	-10.2	-3.5	-4.6	-11.4	-9.9	-4.2	1.1	8.4	7.6	12.8	5.6	-0.4
19	-3.6	-9.8	-3.0	-3.5	-11.9	-8.7	-1.9	0.9	4.2	7.2	11.8	6.8	0.2
20	-5.7	-8.1	-5.9	-3.3	-8.6	-13.5	-1.9	1.5	3.2	9.7	11.9	6.7	-1.8
21	-9.4	-10.1	-4.4	-2.6	-10.8	-16.9	-2.2	1.1	4.1	10.7	12.8	4.4	-0.7
22	-7.9	-16.3	-6.3	-9.1	-14.1	-15.9	-1.5	1.9	7.2	8.8	11.9	5.3	-0.6
23	-2.8	-17.4	-10.0	-10.2	-15.3	-16.3	0.0	0.9	2.4	4.9	10.1	5.9	-1.9
24	-1.6	-17.3	-11.0	-13.8	-17.0	-13.6	-0.7	1.8	3.8	3.7	7.4	5.3	-0.7
25	-2.3	-13.5	-8.9	-17.1	-10.7	-8.8	-0.9	2.0	3.4	4.5	6.8	4.4	-2.4
26	-4.9	-7.4	-6.8	-12.9	-8.6	-5.1	1.4	-0.1	4.3	7.3	8.1	4.2	-4.8
27	-5.5	-10.0	-6.6	-6.7	-4.3	-2.7	2.1	1.1	3.3	6.5	5.4	3.1	-2.9
28	-5.6	-12.1	-4.5	-1.2	-4.6	-2.8	0.6	-0.3	4.5	5.6	6.6	0.7	-2.5
29	-3.4	-14.1	-3.5	-1.8		-2.1	5.8	-0.1	4.7	5.1	6.5	0.4	-1.5
30	-5.0	-12.9	-3.3	-3.6		0.3	7.1	0.9	4.4	5.2	5.1	0.5	-1.4
31	-6.7		-3.5	-4.9		-1.5		1.4		5.8	5.4		-2.1
Month:	-2.2	-8.8	-6.3	-6.4	-7.2	-8.3	-0.9	1.7	4.9	7.1	7.7	4.8	-1.1
											1995 Hydrologic Year:		-1.1

Table 6. Differences in air temperature, precipitation gage catch, and snow accumulation between measurement sites and the weather station located at 990 meters altitude in the Wolverine Glacier Basin, Alaska

[Z, altitude of measurement site in meters (m); δT, average difference in air temperature between the weather station and the glacier observation sites, A, B, and C calculated using the measured average air temperature gradient of -0.0058°C/m for the area (see End-of-year estimates section); °C degrees Celsius; $\delta b(s)/P$, ratio of snow accumlation measured at a site, divided by the precipitation gage catch for the same period, see table 7]

Site	Altitude Z (m)	Air Temperature Difference δT (°C)	Snow Accumulation/ Gage Catch Ratio $\delta b(s)/P$
C	1290	-1.6	3.69
B	1070	-0.5	2.71
Weather Station	990	----	----
A	590	2.2	1.41

Table 7. Ratio between snow accumulation at the measurement sites and the gage catch of precipitation recorded during winter at the weather station located at 990 meters altitude in the Wolverine Glacier Basin, Alaska

[Precipitation gage catch, P, since the previous snow balance measurement; snow balance, $b(s)$, in meters water equivalent, m(w); s.e., standard error of the mean; $\delta b(s)/P$, ratio between the increase in snow mass balance measured at a site, divided by the precipitation gage catch for the same period; m/d/y, month/day/year. Daily values of precipitation gage catch from Mayo and others, 1992]

Date	Site A Snow $b(s)$	Gage Catch P	Ratio $\delta b(s)/P$	Date	Site B Snow $b(s)$	Gage Catch P	Ratio $\delta b(s)/P$	Date	Site C Snow $b(s)$	Gage Catch P	Ratio $\delta b(s)/P$
m/d/y	m(w)	m(w)		m/d/y	m(w)	m(w)		m/d/y	m(w)	m(w)	
10/09/68	0.01			10/05/68	0.13			10/10/68	0.32		
1/28/69	0.24	0.185	1.2	1/27/69	0.67	0.185	2.9	1/25/69	0.94	0.163	3.8
4/13/69	0.62	0.225	1.7	4/12/69	1.42	0.212	3.5	4/18/69	2.52	0.228	6.9
								6/03/69	2.79	0.102	2.6
11/23/69	0.03			11/19/69	0.50						
4/18/70	1.54	0.698	2.2	4/11/70	2.63	0.658	3.2	9/29/70	0.08		
								1/08/71	0.88	0.358	2.2
1/09/71	0.24			1/11/71	0.65			4/27/71	2.58	0.364	4.7
4/27/71	0.87	0.422	1.5	4/27/71	2.13	0.419	3.5				
								10/19/71	0.52		
1/11/72	0.10			1/13/72	0.65			1/13/72	0.86	0.182	1.9
4/08/72	0.12	0.084	0.2	4/10/72	0.79	0.084	1.7	4/10/72	1.07	0.084	2.5
10/01/72	0.003			10/03/72	0.003						
1/06/73	0.23	0.211	1.1	1/04/73	0.54	0.206	2.6	10/03/72	0.01		
4/19/73	0.75	0.268	1.9	4/16/73	1.22	0.266	2.6	1/08/73	0.85	0.211	4.0
								4/17/73	1.90	0.264	4.0
10/15/73	0.02			10/12/73	0.07			6/03/73	2.40	0.115	4.3
3/09/74	0.33	0.310	1.0	3/06/74	0.85	0.301	2.6				
										Average	3.69
10/01/74	0.00			10/01/74	0.00					s.e.	0.50
2/08/75	0.58	0.426	1.4	2/07/75	1.06	0.425	2.5				
10/25/75	0.06			10/27/75	0.15						
2/25/76	0.47	0.281	1.5	2/25/76	0.87	0.280	2.6				
10/24/77	0.19			10/24/77	0.45						
3/02/78	1.17	0.548	1.8	3/01/78	1.60	0.548	2.1				
		Average	1.41			Average	2.71				
		s.e.	0.16			s.e.	0.17				

Table 8. Daily and monthly precipitation gage catch at the weather station located at 990 meters altitude in Wolverine Glacier Basin, Alaska, during the 1995 hydrologic year and October 1995, the first month of the 1996 hydrologic year

[Total gage catch measured daily starting at midnight Alaska Standard Time from the continous record of precipitation; data in millimeters water equivalent; gage catch may not equal actual precipitation because of precipitation catch efficiency errors caused by wind]

Day	Oct. 94	Nov. 94	Dec. 94	Jan. 95	Feb. 95	Mar. 95	Apr. 95	May 95	Jun. 95	Jul. 95	Aug. 95	Sep. 95	Oct. 95
1	0	0	0	0	0	1	0	0	2	3	0	1	1
2	15	8	0	2	3	0	2	0	2	0	0	0	0
3	3	9	26	47	0	5	1	0	1	5	0	1	0
4	0	2	7	2	0	3	1	0	0	0	1	1	0
5	5	1	5	0	16	2	1	0	1	0	7	4	1
6	5	0	0	1	10	0	3	0	2	0	1	8	0
7	6	2	0	1	3	0	3	15	8	5	3	33	0
8	4	1	4	0	19	0	1	5	1	0	0	23	0
9	2	1	0	0	2	0	0	1	0	0	0	3	0
10	0	4	0	3	0	2	1	1	0	5	0	12	1
11	5	0	1	3	7	0	0	0	0	0	0	6	1
12	6	2	3	1	3	2	3	1	0	4	16	0	1
13	2	0	1	0	2	2	2	3	1	0	2	3	2
14	1	1	1	0	1	2	0	0	1	0	0	0	1
15	0	5	0	0	3	0	15	0	0	0	0	0	3
16	5	1	6	0	1	14	2	0	0	2	0	8	0
17	3	8	0	1	1	32	8	0	0	0	0	0	0
18	0	1	5	0	0	1	5	0	0	0	0	9	5
19	0	0	2	3	0	2	1	0	1	0	0	113	0
20	0	5	2	4	0	3	5	0	0	0	0	16	1
21	0	1	1	3	0	3	3	0	0	0	0	21	2
22	0	4	4	5	1	0	2	2	0	0	0	4	4
23	0	0	3	2	1	0	0	1	2	1	0	4	1
24	7	0	1	2	0	0	3	5	0	16	2	27	4
25	1	0	0	4	0	0	1	11	0	4	0	0	1
26	2	0	0	0	0	0	7	2	0	1	0	0	2
27	1	1	3	0	6	0	0	2	0	0	3	2	1
28	1	1	7	0	0	3	0	2	0	3	0	7	0
29	0	0	8	1		5	0	0	12	10	0	8	8
30	0	0	0	5		5	0	0	7	3	11	13	6
31	1		5	5		1		0		11	3		0
Total:	75	58	95	95	79	88	70	51	41	73	49	327	46
												1995 Hydrologic Year:	1,101

Table 9. Icemelt rate in late summer at site A on Wolverine Glacier, Alaska, as a function of air temperature in degree-days above 0 degrees Celsius

[Calculated from data in tables 2 and 5 of this report, and Appendix 1 in Mayo and others (1992); $b'(i)$, ice balance referenced to the bottom of the stake; $\delta b(i)$, change in old firn and ice balance caused by melt; $^{\circ}d{>}0^{\circ}C$, Celsius degree-days above $0^{\circ}C$ at site A during the icemelt period; m/d/y, month/day/year; m(w), meters water equivalent, s.e., standard error of the mean]

Date	Ice balance $b'(i)$	Icemelt $\delta b(i)$	Degree-days $^{\circ}d{>}0^{\circ}C$	Icemelt rate $\delta b(i)/^{\circ}d$
m/d/y	m(w)	m(w)	°d	m(w)/°d
	Stake 67-4			
9/18/67	2.03			
10/14/67	1.77	-0.26	115	-0.0023
	Stake 68-4			
8/20/68	1.89			
9/29/68	1.08	-0.81	390	-0.0021
	Stake 70-4			
7/22/70	6.48			
9/27/70	4.23	-2.25	399	-0.0056
	Stake 72-4			
8/19/72	5.40			
9/29/72	4.30	-1.10	215	-0.0051
	Stake 73-4			
8/25/73	1.62			
10/01/73	0.85	-0.77	163	-0.0047
	Stake 74-4			
9/22/74	0.45			
9/30/74	0.36	-0.09	25	-0.0035
	Stake 75-A2			
8/20/75	7.61			
10/08/75	5.32	-2.29	304	-0.0075
	Stake 75-A2			
7/12/76	4.08			
9/27/76	0.72	-3.36	516	-0.0065
	Stake 79-6.9A			
8/11/79	3.96			
10/27/79	1.65	-2.31	557	-0.0041
	Stake 80-A			
9/02/80	7.33			
9/19/80	7.20	-0.13	43	-0.0030
			Average	-0.0045
			s.e.	0.0005

Table 10. Summary of yearly surface net mass balance and annual mass balance measured at sites A, B, and C on Wolverine Glacier, Alaska from 1996 to 1995

[b_n, yearly net balance, and b_a, annual balance, in meters water equivalent, m(w); --- indicates no year-end results]

Glacier Mass Balance						
Measurement	Site A		Site B		Site C	
Year	Net b_n m(w)	Annual b_a m(w)	Net b_n m(w)	Annual b_a m(w)	Net b_n m(w)	Annual b_a m(w)
1966	-4.92	---	-1.00	---	0.58	---
1967	-5.09	---	-2.00	---	-1.00	---
1968	-3.89	-4.02	-1.44	-1.48	0.45	0.26
1969	---	---	-0.94	-0.91	1.03	0.86
1970	-2.63	-2.83	0.87	0.82	2.85	2.91
1971	-2.70	---	-0.19	---	1.30	---
1972	-4.30	---	-1.34	---	-0.59	---
1973	-3.59	-3.59	-0.11	-0.08	1.47	1.51
1974	-5.21	-5.21	-1.75	-1.79	0.32	0.41
1975	-4.27	-4.00	-0.75	-0.69	0.97	1.04
1976	-4.60	-4.83	-1.49	-1.45	0.17	0.46
1977	-3.19	-2.93	0.15	0.06	3.38	2.96
1978	-3.86	-4.08	-0.45	-0.48	2.04	2.01
1979	-5.89	-5.67	-2.38	-2.27	---	---
1980	-1.96	-2.16	0.81	0.70	---	---
1981	-2.65	-2.63	0.89	0.92	5.32	5.59
1982	-4.70	-4.81	-1.00	-1.01	1.30	1.08
1983	-4.19	-4.12	-1.01	-1.02	1.09	1.10
1984	-5.32	-5.20	-1.20	-1.19	1.27	1.40
1985	-3.18	-3.27	-0.20	-0.01	1.73	1.92
1986	-4.45	-4.24	-2.03	-2.23	0.86	0.54
1987	-3.30	-3.55	0.41	0.58	3.00	3.46
1988	-2.58	-2.48	0.37	0.19	2.50	2.21
1989	---	---	-2.25	-2.22	0.13	0.06
1990	-6.18	-6.26	-3.07	-3.09	-0.86	-0.73
1991	-4.04	-4.12	-1.34	-1.10	0.96	1.21
1992	-3.24	-3.14	-1.19	-1.41	1.81	1.48
1993	-4.35	-4.13	-1.56	-1.50	0.67	0.88
1994	-5.33	-5.37	-1.34	-1.31	1.29	1.25
1995	-4.67	-4.71	-1.34	-1.40	1.04	0.92
Average:	-4.08	-4.06	-0.93	-0.90	1.25	1.45

Table 11. Evolution of the project grid coordinates of survey monumnets in Wolverine Glacier Basin, Alaska, and coordinate changes to Net79, the coordinate system used to report the glacier data

[Coordinates, *X, Y,* and *Z*, and their changes, δ*X,* δ*Y*, and δ*Z*, in meters (m), shown only for those monuments defined in two or more networks "Nets". Project grid projection at sea level; origin and azimuths based on the UTM system, see equations 2 and 3 for conversion to UTM coordinates]

MONUMENT	Project Grid Net76			Project Grid Net79			Coordinate Change		
	X (m)	*Y* (m)	*Z* (m)	*X* (m)	*Y* (m)	*Z* (m)	δ*X* (m)	δ*Y* (m)	δ*Z* (m)
COBRA	2853.61	8110.09	1468.72	2857.46	8097.24	1468.32	3.85	-12.85	-0.40
FUSS	753.10	7351.78	1499.83	757.47	7339.35	1499.40	4.37	-12.43	-0.43
BLEW IT	5820.51	6530.66	1653.70	5823.96	6517.39	1653.26	3.45	-13.27	-0.44
STYLUS	5066.45	5444.01	1509.37	5069.55	5431.17	1508.95	3.10	-12.84	-0.42
LICHEN	1670.26	5156.90	1289.74	1673.69	5144.69	1289.44	3.43	-12.21	-0.30
MOON	3963.02	3841.91	1065.31	3965.83	3829.29	1065.16	2.81	-12.62	-0.15
WINDY	1637.10	2795.30	952.84	1640.23	2783.40	952.61	3.13	-11.90	-0.23
PRECIP	1343.36	2931.46	991.34	1346.61	2919.58	991.11	3.25	-11.88	-0.23
VIBRATIONS	1860.43	1618.99	775.00	1863.29	1607.22	774.80	2.86	-11.77	-0.20
MEADOW	2878.30	1921.43	637.16	2880.67	1909.74	637.14	2.37	-11.69	-0.02
after 2/25/76			638.50			638.48			-0.02
SPREAD	3903.60	752.61	412.21	3905.89	740.80	412.13	2.29	-11.81	-0.08
						Average:	3.17	-12.30	-0.24

MONUMENT	Project Grid Net77			Project Grid Net79			Coordinate Change		
	X (m)	*Y* (m)	*Z* (m)	*X* (m)	*Y* (m)	*Z* (m)	δ*X* (m)	δ*Y* (m)	δ*Z* (m)
COBRA	2853.19	8108.89	1468.12	2857.46	8097.24	1468.32	4.27	-11.65	0.20
FUSS	752.99	7350.53	1499.21	757.47	7339.35	1499.40	4.48	-11.18	0.19
BLEW IT	5819.65	6529.69	1653.03	5823.96	6517.39	1653.26	4.31	-12.30	0.23
STYLUS	5065.70	5443.20	1508.70	5069.55	5431.17	1508.95	3.85	-12.03	0.25
LICHEN	1670.01	5156.14	1289.15	1673.69	5144.69	1289.44	3.68	-11.45	0.29
MOON	3962.43	3841.34	1064.85	3965.83	3829.29	1065.16	3.40	-12.05	0.31
WINDY	1636.85	2794.89	952.42	1640.23	2783.40	952.61	3.38	-11.49	0.19
PRECIP	1343.17	2931.03	990.92	1346.61	2919.58	991.11	3.44	-11.45	0.19
VIBRATIONS	1860.15	1618.74	774.57	1863.29	1607.22	774.80	3.14	-11.52	0.23
MEADOW	2877.87	1921.15	638.18	2880.67	1909.74	638.48	2.80	-11.41	0.30
SPREAD	3903.02	752.52	411.73	3905.89	740.80	412.13	2.87	-11.72	0.40
						Average:	3.60	-11.66	0.25

MONUMENT	Project Grid Net78.04			Project Grid Net79			Coordinate Change		
	X (m)	*Y* (m)	*Z* (m)	*X* (m)	*Y* (m)	*Z* (m)	δ*X* (m)	δ*Y* (m)	δ*Z* (m)
COBRA	2853.13	8108.63	1468.10	2857.46	8097.24	1468.32	4.33	-11.39	0.22
FUSS	753.38	7350.44	1499.18	757.47	7339.35	1499.40	4.09	-11.09	0.22
BLEW IT	5819.71	6529.37	1653.03	5823.96	6517.39	1653.26	4.25	-11.98	0.23
STYLUS	5065.53	5443.08	1508.70	5069.55	5431.17	1508.95	4.02	-11.91	0.25
LICHEN	1669.93	5156.05	1289.20	1673.69	5144.69	1289.44	3.76	-11.36	0.24
MOON	3962.15	3841.11	1064.97	3965.83	3829.29	1065.16	3.68	-11.82	0.19
WINDY	1636.85	2794.89	952.42	1640.23	2783.40	952.61	3.38	-11.49	0.19
PRECIP	1343.21	2931.03	990.92	1346.61	2919.58	991.11	3.40	-11.45	0.19
VIBRATIONS	1860.11	1618.64	774.60	1863.29	1607.22	774.80	3.18	-11.42	0.20
MEADOW	2877.56	1921.35	636.91	2880.67	1909.74	637.14	3.11	-11.61	0.23
after 2/25/76			638.25			638.48			0.23
SPREAD	3902.85	752.67	411.94	3905.89	740.80	412.13	3.04	-11.87	0.19
						Average:	3.66	-11.58	0.22

MONUMENT	Project Grid Net78.06			Project Grid Net79			Coordinate Change		
	X (m)	*Y* (m)	*Z* (m)	*X* (m)	*Y* (m)	*Z* (m)	δ*X* (m)	δ*Y* (m)	δ*Z* (m)
COBRA	2853.20	8108.94	1468.13	2857.46	8097.24	1468.32	4.26	-11.70	0.19
FUSS	753.34	7350.70	1499.21	757.47	7339.35	1499.40	4.13	-11.35	0.19
BLEW IT	5819.96	6529.58	1653.07	5823.96	6517.39	1653.26	4.00	-12.19	0.19
STYLUS	5065.73	5443.23	1508.76	5069.55	5431.17	1508.95	3.82	-12.06	0.19
LICHEN	1669.92	5156.19	1289.25	1673.69	5144.69	1289.44	3.77	-11.50	0.19
FALL	4517.74	5524.35	1362.24	4521.57	5512.38	1362.43	3.83	-11.97	0.19
MOON	3962.28	3841.17	1064.97	3965.83	3829.29	1065.16	3.55	-11.88	0.19
SNOWY	1760.39	3156.24	933.34	1763.83	3144.73	933.53	3.44	-11.51	0.19
WINDY	1636.85	2794.89	952.42	1640.23	2783.40	952.61	3.38	-11.49	0.19
FOGGY	1484.21	2599.75	933.93	1487.55	2588.28	934.12	3.34	-11.47	0.19
PRECIP	1343.21	2931.02	990.92	1346.61	2919.58	991.11	3.40	-11.44	0.19
VIBRATIONS	1860.11	1618.75	774.61	1863.29	1607.22	774.80	3.18	-11.53	0.19
MEADOW	2877.44	1921.44	638.29	2880.67	1909.74	638.48	3.23	-11.70	0.19
SPREAD	3902.85	752.67	411.94	3905.89	740.80	412.13	3.04	-11.87	0.19
						Average:	3.60	-11.69	0.19

Table 12. Glacier motion and surface altitude data from site A (590 meters altitude) on Wolverine Glacier, Alaska

[*X, Y,* and *Z*, coordinates of the stake base, E indicates estimate using measurement of a nearby stake, see Glacier motion section for method; *S*, average speed; θ, horizontal glacier surface motion direction, positive counterclockwise from grid East; ϕ, dip of glacier surface motion, positive up from hoizontal; Z_I, glacier surface altitude at fixed-location measurement site; *d* snow depth; Z_{ss}, summer surface altitude at the fixed-location site; *b'*, stake reading (either *b', b**, or *b*** from tables 2, 3, and 4), height of glacier surface above the stake base; *e*, glacier motion emergence, the amount of ice motion rise (+) upward toward the surface; submergence (-) downward, the amount a glacier would change in thickness at a site with a mass balance of zero; S_e, emergence speed; motion terminology after Meier, 1960; ---, no data available. See Glacier motion and surface altitudes section for method of measurement. Abbreviations: m/d/y, month/day/year, yr, year; m, meter; grad, a measure of angle, a right angle is 100 grad]

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b′	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
STAKE 75-A													
2/08/75		2465.1	1726.7	590.2				600.5	1.6	598.9	7.8		
5/31/75	0.307	2469.9	1714.9	590.6	41.6	-75.4	2.0	601.4	1.3	600.1	7.6	1.1	3.6
8/17/75	0.214	2474.5	1705.7	589.6	48.4	-70.5	-6.2	597.8	0.0	597.8	3.5	0.5	2.3
STAKE 75-A2													
2/08/75		2447.2	1771.8	592.1				600.5	1.6	598.9	12.2		
5/31/75	0.307	2452.0	1760.0	592.5 E	41.6	-75.4	2.0	601.4	1.3	600.1	12.0 E	1.1	3.6
10/25/75	0.709	2458.0	1742.3	589.9	26.6	-79.2	-8.8	596.0	0.2	595.8	6.1	0.5	0.7
2/25/76	0.337	2464.4	1731.1	590.5	38.3	-67.0	3.0	599.3	1.3	598.0	7.2 E	2.2	6.5
7/12/76	0.378	2470.7	1717.3	590.3	40.2	-72.7	-0.8	598.6	0.0	598.6	4.5	2.0	5.3
10/19/76	0.271	2475.9	1706.3	588.3	45.5	-71.9	-10.4	594.6	0.1	594.5	0.9	-0.4	-1.5
STAKE 77-A													
2/23/77		2468.1	1797.2	602.0				602.6	4.7	597.9	5.0 E		
6/10/77	0.293	2472.7	1783.9	602.7 E	48.1	-78.8	3.2	603.5	3.3	600.2	3.6 E	2.3	7.9
		Stake slipped down 1.69 m, see balance data; stake altitude, *Z*, and stake reading, *b'*, adjusted for the measured stake slip.											
STAKE 77-A2													
6/10/77		2477.7	1797.7	597.2				603.5	3.5	600.0	10.6		
10/24/77	0.372	2483.8	1778.6	593.2	54.9	-80.3	-12.5	596.0	0.6	595.4	4.1	-1.0	-2.7
3/02/78	0.353	2489.3	1765.4	593.4	40.5	-74.9	0.9	600.6	3.0	597.6	6.5	2.2	6.2
6/04/78	0.257	2494.0	1755.6	593.5	42.2	-71.5	0.6	601.3	1.8	599.5	5.3	1.9	7.4
STAKE 78-6.9A													
3/02/78		2492.2	1802.1	594.3				600.6	3.2	597.4	10.8		
6/04/78	0.257	2497.0	1791.3	594.7	46.0	-73.4	2.2	601.3	1.9	599.4	9.5	2.0	7.8
9/28/78	0.318	2503.6	1774.7	590.8	57.5	-75.9	-13.7	593.9	0.0	593.9	3.4	-1.3	-4.1
		Stake reset.											
9/28/78		2503.5	1773.6	592.6				593.9	0.0	593.9	1.4		
3/14/79	0.457	2510.3	1757.6	592.3	38.0	-74.4	-1.1	598.3	1.9	596.4	3.2	2.6	5.7
STAKE 78-6.9A2													
3/02/78		2493.5	1800.5	595.4				600.6	3.2	597.4	10.1		
6/04/78	0.257	2497.8	1789.4	595.1	46.3	-76.5	-1.6	601.3	1.9	599.4	8.8	2.0	7.8
9/28/78	0.318	2503.4	1772.5	591.2	57.3	-79.6	-13.7	593.9	0.0	593.9	2.7	-1.3	-4.1
STAKE 79-6.9A													
3/14/79		2485.4	1800.1	592.4				598.3	2.0	596.3	10.4		
8/11/79	0.411	2492.0	1780.2	589.8	51.4	-79.6	-7.9	592.9	0.0	592.9	4.4	0.6	1.5
1/11/80	0.419	2497.9	1763.2	587.3	43.4	-78.7	-8.8	591.9	1.4	590.5	3.2	0.2	0.5
6/04/80	0.397	2503.8	1749.7	588.0	37.2	-73.8	3.0	596.1	3.3	592.8	5.1	2.3	5.8
STAKE 80-A													
1/11/80		2482.7	1792.7	584.3				591.9	1.4	590.5	10.9		
6/04/80	0.397	2488.6	1779.2	585.0 E	37.2	-73.8	3.0	596.1	3.3	592.8	12.8 E	2.3	5.8
9/02/80	0.246	2494.0	1765.3	582.6	61.4	-76.4	-10.2	591.9	0.0	591.9	8.3	0.3	1.2
1/26/81	0.400	2499.7	1752.1	581.8	36.0	-74.0	-3.5	594.3	2.2	592.1	9.6	1.1	2.8
6/02/81	0.348	2505.6	1737.4	581.8	45.5	-75.7	0.0	596.9	2.3	594.6	9.6	2.6	7.5
9/01/81	0.249	2509.9	1727.1	579.8	45.5	-74.8	-11.3	592.2	0.0	592.2	5.1	-0.2	-0.8
1/22/82	0.392	2518.2	1710.5	578.6	47.4	-70.5	-4.1	593.8	1.0	592.8	5.4	1.3	3.3
6/25/82	0.422	2527.0	1693.6	579.0	45.2	-69.4	1.3	596.4	0.0	596.4	3.9	4.1	9.7

Table 12. Glacier motion and surface altitude data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b'	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
				STAKE 82-A									
6/25/82		2502.8	1747.1	584.0				596.4	0.0	596.4	7.1		
9/02/82	0.189	2506.2	1738.1	582.2	51.8	-77.0	-11.8	590.9	0.0	590.9	3.3	-1.7	-9.0
1/14/83	0.367	2512.8	1724.3	581.7	41.7	-71.6	-2.1	594.0	1.6	592.4	4.1	2.3	6.3
6/11/83	0.405	2521.5	1707.4	581.8	46.9	-69.7	0.3	596.5	0.8	595.7	3.3	3.3	8.1
				STAKE 83-A									
6/11/83		2456.6	1790.7	591.2				596.5	0.8	595.7	8.1		
9/02/83	0.227	2460.7	1777.2	588.4	63.4	-81.2	-12.5	590.9	0.0	590.9	3.5	-1.0	-4.4
1/18/84	0.378	2466.6	1761.8	588.5	43.6	-76.7	0.4	594.6	1.8	592.8	4.4	2.8	7.4
6/10/84	0.394	2475.1	1742.4	588.6	53.8	-73.7	0.3	595.7	0.6	595.1	3.2	2.3	5.8
				STAKE 84-A									
6/10/84		2494.5	1789.8	589.3				595.7	0.6	595.1	9.3		
8/17/84	0.186	2499.0	1778.5	587.0	66.6	-75.9	-11.9	590.9	0.0	590.9	4.8	-0.3	-1.6
1/12/85	0.405	2509.0	1755.0	583.7	63.6	-74.4	-8.2	591.3	1.5	589.8	4.3	0.9	2.2
6/08/85	0.402	2515.0	1741.2	584.7	37.5	-73.9	4.2	595.3	2.0	593.3	4.7	3.6	9.0
8/27/85	0.219	2519.5	1729.9	583.2	56.0	-75.9	-7.8	593.2	0.0	593.2	0.5	2.1	9.6
				STAKE 85-A									
6/08/85		2465.6	1815.0	594.2				595.3	1.8	593.5	8.7		
8/27/85	0.219	2469.0	1802.1	592.0	61.7	-83.6	-10.4	593.2	0.0	593.2	4.4	2.2	10.0
2/17/86	0.476	2478.1	1779.3	591.0	51.6	-75.8	-2.6	596.5	2.7	593.8	6.1	1.6	3.4
6/14/86	0.320	2484.6	1762.4	591.1	56.6	-76.6	0.4	596.2	0.9	595.3	4.3	1.5	4.7
				STAKE 86-A									
6/14/86		2481.8	1790.1	590.9				596.2	0.8	595.4	8.7		
8/20/86	0.183	2485.7	1777.8	588.6	71.6	-80.5	-11.2	591.7	0.0	591.7	4.5	-0.3	-1.6
6/14/87	0.816	2503.4	1737.4	586.6	54.1	-73.7	-2.9	597.0	1.7	595.3	4.7 E	5.1	6.3
				STAKE 87-A									
6/15/87		2453.8	1827.4	601.7				597.0	1.7	595.3	6.6		
10/01/87	0.296	2459.7	1807.0	596.3	74.0	-82.1	-15.9	590.9	0.0	590.9	1.3	-0.8	-2.7
				STAKE 87-A2									
10/01/87		2452.0	1856.9	600.4				590.9	0.0	590.9	6.1		
3/19/88	0.465	2461.8	1828.2	598.3 E	65.4	-79.1	-4.4	599.7	4.1	595.6	9.9 E	5.0	10.8
6/09/88	0.225	2467.3	1813.2	598.5	71.0	-77.6	0.8	599.6	2.6	597.0	8.4	1.4	6.2
9/18/88	0.277	2473.0	1793.9	595.1	73.7	-81.7	-10.7	593.9	0.0	593.9	3.2	-0.5	-1.8
6/15/89	0.739	2491.1	1750.7	594.0	63.4	-74.7	-1.5	599.2	0.0	599.2	2	6.5	8.8
				STAKE 88-A									
3/19/88		2459.4	1833.8	605.0				599.7	4.9	594.8	4.9		
6/09/88	0.225	2464.9	1818.8	605.2	71.0	-77.6	0.8	599.6	2.6	597.0	2.6	2.2	9.8
				STAKE 89-A									
10/03/89		2474.7	1823.5	593.3				592.2	0.0	592.2	7.9		
2/14/90	0.367	2481.4	1804.9	592.5	53.9	-78.0	-2.6	596.4	1.7	594.7	9.4	2.7	7.4
6/02/90	0.296	2487.8	1788.1	591.7	60.8	-76.8	-2.8	597.0	0.0	597.0	7.8	2.2	7.4
9/07/90	0.266	2492.8	1771.3	588.3	67.1	-81.6	-12.2	590.1	0.0	590.1	1.4	-0.5	-1.9
				STAKE 90-A									
9/10/90		2492.8	1771.3	581.4				590.1	0.0	590.1	8.1		
1/07/91	0.326	2497.9	1757.8	580.7	44.3	-77.0	-3.1	590.9	0.1	590.8	7.8	1.1	3.4
5/13/91	0.345	2504.2	1743.5	580.8	45.3	-73.6	0.4	594.8	1.8	593.0	9.4	2.3	6.7
9/18/91	0.350	2512.6	1726.1	578.1	55.7	-71.4	-8.8	588.6	0.0	588.6	3.2	0.0	0.0

Table 12. Glacier motion and surface altitude data from site A (590 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates			Glacier Motion Vector Speed	Direction	Slope	Surface Altitude	Snow Depth	Summer Surface Altitude	Stake Reading	Emergence Rise	Emergence Speed
		X	Y	Z	S	θ	ϕ	Z_I	d	Z_{ss}	b'	e	S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
				STAKE 91-A									
9/18/91		2453.1	1813.5	585.7				588.6	0.0	588.6	8.9		
1/23/92	0.348	2458.4	1798.5	585.0	45.8	-78.4	-2.8	591.5	1.8	589.7	10.7	1.1	3.2
5/13/92	0.304	2463.7	1784.8	585.2	48.3	-76.5	0.9	593.6	1.9	591.7	10.8	2.0	6.6
9/06/92	0.318	2469.3	1767.4	582.0	58.4	-80.2	-11.0	588.0	0.0	588.0	5.7	-0.5	-1.6
2/09/93	0.427	2476.4	1751.0	582.1	41.9	-74.0	0.4	591.5	1.6	589.9	6.9	2.3	5.4
5/16/93	0.263	2481.6	1739.4	582.2	48.3	-73.2	0.5	594.3	1.9	592.4	7.2	2.5	9.5
				STAKE 92-A									
9/07/92		2463.3	1839.4	589.6				588.0	0.0	588.0	8		
2/09/93	0.424	2469.4	1818.9	588.8 E	50.5	-81.6	-2.4	591.5	1.6	589.9	9.6 E	1.9	4.5
5/16/93	0.263	2474.6	1807.3	588.9	48.3	-73.2	0.5	594.3	1.8	592.5	9.3	3.1	11.8
9/10/93	0.320	2480.9	1788.7	584.9	62.6	-79.2	-12.8	585.9	0.0	585.9	3.7	-2.8	-8.8
2/05/94	0.405	2487.5	1772.5	584.2	43.2	-75.4	-2.5	588.7	2.0	586.7	4.7	1.8	4.4
5/14/94	0.268	2492.0	1761.8	584.3	43.3	-74.7	0.5	590.6	1.8	588.8	4.6	2.0	7.5
				STAKE 93-A									
9/13/93		2492.8	1797.2	580.5				585.9	0.0	585.9	9.1		
2/05/94	0.397	2499.6	1780.6	579.5	45.3	-75.2	-3.5	588.7	1.7	587.0	10.6	1.3	3.3
5/14/94	0.268	2504.3	1770.4	579.5	41.9	-72.5	0.0	590.6	1.8	588.8	10.6	1.9	7.1
9/09/94	0.323	2509.3	1754.1	577.1	53.3	-81.1	-8.9	583.3	0.0	583.3	3.2	0.1	0.3
1/31/95	0.394	2514.9	1741.9	576.7	34.1	-72.6	-1.9	586.5	1.9	584.6	4.8	1.6	4.1
5/14/95	0.282	2520.6	1730.6	576.3	44.9	-70.3	-2.0	588.1	1.9	586.2	4.7	1.7	6.0
				STAKE 94-A									
9/09/94		2487.2	1798.6	577.7				583.3	0.0	583.3	9.9		
1/31/95	0.394	2492.4	1784.6	577.3	37.9	-77.4	-1.7	586.5	1.9	584.6	11.2	1.9	4.8
5/14/95	0.282	2497.6	1772.2	576.8	47.7	-74.7	-2.4	588.1	1.9	586.2	11.2	1.6	5.7
9/14/95	0.337	2503.4	1756.7	574.1	49.8	-77.2	-10.3	581.9	0.0	581.9	5.2	-0.2	-0.6
1/12/96	0.329	2508.5	1745.6	573.2	37.2	-72.6	-4.7	583.0	1.0	582.0	5.1	1.2	3.6
				Average:	50.0	-75.7	-4.1	594.2	1.2	593.0	6.5	1.4	3.6

Table 13. Glacier motion and surface altitude data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska

[*X, Y,* and *Z*, coordinates of the stake base, E indicates estimate using measurement of a nearby stake, see Glacier motion section for method; *S*, average speed; θ, horizontal glacier surface motion direction, positive counterclockwise from grid East; ϕ, dip of glacier surface motion, positive up from hoizontal; Z_I, glacier surface altitude at fixed-location measurement site; *d* snow depth; Z_{ss}, summer surface altitude at the fixed-location site; *b′*, stake reading (either *b′, b**, or *b*** from tables 2, 3, and 4), height of glacier surface above the stake base; *e*, glacier motion emergence, the amount of ice motion rise (+) upward toward the surface; submergence (-) downward, the amount a glacier would change in thickness at a site with a mass balance of zero; S_e, emergence speed; motion terminology after Meier, 1960; ---, no data available. See Glacier motion and surface altitudes section for method of measurement. Abbreviations: m/d/y, month/day/year, yr, year; m, meter; grad, a measure of angle, a right angle is 100 grad]

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b′	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
STAKE 75-B; located 300-400 m northeast of site B.													
2/07/75		3169.8	5113.9	1063.9					2.6	----	9.7		
6/03/75	0.318	3178.9	5095.4	1062.7	65.0	-70.9	-3.7	----	3.5	----	10.6	----	----
10/27/75	0.400	3187.8	5073.8	1061.1	58.6	-75.1	-4.4	----	0.5	----	6.8	----	----
2/23/76	0.326	3194.2	5055.8	1060.9	58.6	-78.3	-0.7	----	2.3	----	8.6	----	----
10/15/76	0.643	3209.0	5015.4	1059.1	66.9	-77.6	-2.7	----	0.8	----	5.6	----	----
STAKE 75-B2													
10/27/75		3059.9	4873.2	1068.2				1064.6	0.6	1064.0	0.6		
2/23/76	0.326	3068.7	4850.5	1067.7	74.6	-76.5	-1.2	1066.6	2.2	1064.4	2.2	0.4	1.2
7/13/76	0.386	3082.0	4819.4	1066.7	87.7	-74.3	-1.9	1066.3	0.9	1065.4	0.9	1.0	2.6
STAKE 76-B													
2/23/76		3068.7	4850.2	1063.0				1066.6	2.3	1064.3	6.9		
7/13/76	0.386	3081.9	4819.4	1062.0	86.8	-74.2	-1.9	1066.3	1.0	1065.3	5.6	1.0	2.6
10/15/76	0.257	3088.1	4801.7	1060.4	73.1	-78.6	-5.4	1064.0	0.8	1063.2	3.7	-0.4	-1.6
10/24/77	1.024	3111.8	4727.5	1056.4	76.2	-80.3	-3.3	1065.3	1.5	1063.8	4.6	0.4	0.4
STAKE 77-B													
2/23/77		3036.9	4842.5	1067.4				1070.1	6.9	1063.2	4.8		
Stake base in the snow above the summer surface.													
6/08/77	0.287	3045.9	4819.9	1066.3	84.7	-75.9	-2.9	1069.5	5.9	1063.6	4.7	-0.5	-1.7
STAKE 77-B2													
6/08/77		3063.1	4823.2	1061.0				1069.5	6.1	1063.4	9.9		
10/24/77	0.378	3073.6	4794.5	1059.6	81.0	-77.7	-2.9	1065.3	1.5	1063.8	5.6	0.1	0.3
3/01/78	0.350	3081.3	4769.1	1058.7	75.8	-81.3	-2.2	1068.5	4.3	1064.2	8.2	0.6	1.7
6/02/78	0.255	3088.5	4747.8	1057.6	88.4	-79.2	-3.1	1068.4	4.8	1063.6	8.7	-0.6	-2.4
STAKE 78-3.7B													
3/01/78		3068.0	4809.4	1059.3				1068.5	4.3	1064.2	10.0		
6/02/78	0.255	3075.8	4788.9	1058.6	86.1	-76.9	-2.0	1069.4	4.6	1064.8	10.3	0.6	2.4
9/29/78	0.326	3085.0	4761.8	1057.4	87.9	-79.2	-2.7	1064.5	0.0	1064.5	5.2	0.2	0.6
3/07/79	0.435	3094.2	4730.0	1055.5	76.2	-82.1	-3.6	1067.3	2.8	1064.5	7.9	0.1	0.2
8/06/79	0.416	3103.4	4697.0	1053.8	82.5	-82.7	-3.2	1064.7	0.0	1064.7	4.8	0.5	1.2
STAKE 79-3.7B													
3/07/79		3082.3	4829.4	1059.8				1067.3	2.8	1064.5	9.0		
8/06/79	0.416	3094.0	4796.4	1058.5	84.2	-78.3	-2.4	1064.7	0.1	1064.6	6.0	0.4	1.0
1/10/80	0.430	3103.7	4766.3	1056.8	73.7	-80.2	-3.4	1065.7	3.1	1062.6	6.8	0.2	0.5
STAKE 80-3.7B													
1/10/80		3079.5	4827.7	1059.2				1065.7	3.1	1062.6	8.1		
6/06/80	0.405	3087.8	4797.2	1057.8 E	78.1	-83.1	-2.8	1069.1	4.2	1064.9	9.2 E	2.3	5.7
9/05/80	0.249	3095.1	4776.9	1056.7	86.7	-78.0	-3.2	1066.3	2.4	1063.9	7.3	-0.9	-3.6
9/01/82	1.988	3135.4	4615.5	1051.5	83.7	-84.4	-2.0	1067.6	0.0	1067.6	3.6	5.0	2.5
STAKE 80-B2													
6/06/80		3065.4	4821.5	1065.2				1069.1	5.6	1063.5	5.6		
9/05/80	0.249	3072.7	4801.2	1064.1	86.7	-78.0	-3.2	1066.3	1.8	1064.5	1.8	1.0	4.0
9/01/81	0.988	3098.2	4716.7	1062.7	89.3	-81.3	-1.0	1068.1	1.6	1066.5	2.6	1.0	1.0
9/01/82	0.999	3116.2	4637.4	1055.6	81.7	-85.8	-5.5	1067.6	0.0	1067.6	1.1	1.0	1.0

Table 13. Glacier motion and surface altitude data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b'	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
STAKE 81-B													
1/27/81		3028.9	4862.5	1070.0				1070.6	5.1	1065.5	5.3		
6/03/81	0.348	3041.1	4831.9	1068.8	94.7	-75.8	-2.3	1071.7	5.3	1066.4	5.4	1.0	2.9
9/01/81	0.246	3048.3	4808.4	1067.3	100.1	-81.1	-3.9	1068.1	1.7	1066.4	1.9	-0.1	-0.4
1/20/82	0.386	3061.0	4777.8	1065.6	85.9	-75.0	-3.3	1070.2	2.1	1068.1	4.0	0.0	0.0
6/26/82	0.430	3070.5	4740.4	1063.3	89.9	-84.2	-3.8	1070.3	1.8	1068.5	3.7	0.4	0.9
9/01/82	0.183	3075.4	4726.1	1062.7	82.7	-79.0	-2.5	1067.6	0.0	1067.6	0.6 E	0.4	2.2
STAKE 81-B2													
9/02/81		3025.0	4868.0	1068.9				1068.1	1.7	1066.4	3.8		
1/20/82	0.383	3037.4	4837.3	1067.2	86.6	-75.6	-3.3	1070.2	2.1	1068.1	5.6	0.3	0.8
6/26/82	0.430	3050.2	4801.1	1065.6	89.4	-78.4	-2.7	1070.3	1.7	1068.6	5.3	0.4	0.9
9/01/82	0.183	3056.0	4785.0	1064.9	93.6	-78.0	-2.6	1067.6	0.0	1067.6	2.2	0.4	2.2
1/14/83	0.370	3065.9	4755.7	1063.3	83.7	-79.3	-3.3	1070.0	2.6	1067.4	4.4	0.2	0.5
6/13/83	0.411	3075.2	4719.7	1061.5	90.6	-83.9	-3.1	1070.5	2.8	1067.7	4.7	0.2	0.5
9/02/83	0.222	3080.2	4700.8	1060.5	88.2	-83.5	-3.3	1067.5	0.0	1067.5	1.0	0.7	3.2
STAKE 83-B													
6/13/83		3059.6	4882.2	1066.5				1070.5	2.7	1067.8	8.6		
9/02/83	0.222	3067.0	4862.8	1065.7	93.6	-76.8	-2.5	1067.5	0.0	1067.5	5.0	0.6	2.7
1/19/84	0.381	3078.4	4832.5	1065.1	85.0	-77.1	-1.2	1070.9	2.6	1068.3	7.4	1.0	2.6
6/08/84	0.386	3090.0	4799.3	1064.0	91.2	-78.6	-2.0	1071.7	2.7	1069.0	7.6	0.6	1.6
8/20/84	0.200	3096.2	4781.4	1062.7	94.9	-78.8	-4.4	1068.1	0.0	1068.1	4.2	-0.2	-1.0
1/13/85	0.400	3105.0	4751.6	1060.9	77.8	-81.7	-3.7	1069.2	2.0	1067.2	5.4	-0.1	-0.3
6/15/85	0.419	3114.7	4717.3	1059.1	85.2	-82.5	-3.2	1070.8	3.1	1067.7	6.5	0.5	1.2
8/27/85	0.200	3118.5	4700.4	1058.2	86.7	-85.9	-3.3	1068.2	0.1	1068.1	3.6	0.3	1.5
2/18/86	0.479	3126.9	4662.2	1056.7	81.7	-86.2	-2.4	1072.5	3.7	1068.8	7.0	0.9	1.9
STAKE 85-BBQ													
6/15/85		3152.2	4893.5	1064.8				1070.8	3.0	1067.8	8.1		
8/27/85	0.200	3157.7	4877.6	1064.6	84.1	-78.8	-0.8	1068.2	0.2	1068.0	5.0	0.5	2.5
2/18/86	0.479	3170.0	4842.7	1064.1	77.3	-78.4	-0.9	1072.5	3.5	1069.0	7.9	1.4	2.9
6/16/86	0.323	3178.2	4817.3	1063.3	82.7	-80.1	-1.9	1071.9	2.8	1069.1	7.2	0.1	0.3
8/20/86	0.178	3182.7	4802.6	1062.4	86.5	-81.1	-3.7	1068.5	0.0	1068.5	4.3	-0.5	-2.8
10/03/89	3.121	3229.0	4558.8	1052.7	79.6	-88.1	-2.5	1069.9	0.0	1069.9	1.3	4.4	1.4
STAKE 85-BP													
6/15/85		3009.2	4883.0	1068.2				1070.8	3.1	1067.7	7.7		
8/27/85	0.200	3016.6	4865.1	1067.5	96.9	-75.0	-2.3	1068.2	0.2	1068.0	4.9	0.2	1.0
2/18/86	0.479	3032.0	4825.8	1066.6	88.1	-76.2	-1.4	1072.5	3.9	1068.6	8.4	0.8	1.7
6/16/86	0.323	3042.3	4797.2	1065.4	94.2	-78.0	-2.5	1071.9	2.7	1069.2	7.4	0.4	1.2
8/20/86	0.178	3048.1	4780.4	1064.4	100.0	-78.8	-3.6	1068.5	0.0	1068.5	4.0	0.0	0.0
10/03/89	3.121	3099.0	4505.5	1049.9	89.7	-88.3	-3.3	1069.9	0.0	1069.9	1.2	4.2	1.3
STAKE 86-B													
6/16/86		3030.2	4906.2	1069.3				1071.9	2.8	1069.1	8.7		
8/20/86	0.178	3037.2	4889.8	1068.3	100.3	-74.3	-3.6	1068.5	0.0	1068.5	5.5	-0.2	-1.1
10/01/87	1.114	3072.0	4794.2	1070.6	91.3	-77.8	1.4	1070.6	0.6	1070.0	5.5	2.1	1.9
10/03/89	2.007	3117.6	4618.0	1056.0	91.0	-81.7	-2.8	1069.9	0.0	1069.9	5.5	-0.7	-0.3
STAKE 86-BL													
2/18/86		3126.1	4661.3	1059.6				1072.5	3.9	1068.6	3.9		
6/16/86	0.323	3131.1	4634.2	1058.4	85.4	-88.4	-2.8	1071.9	3.0	1068.9	3.0 E	0.3	0.9

Table 13. Glacier motion and surface altitude data from site B (1,070 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b'	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
				STAKE 87-B									
6/13/87		3039.7	4850.6	1066.9				1073.4	4.3	1069.1	9.2		
10/01/87	0.301	3049.6	4823.9	1065.7	94.7	-77.4	-2.7	1070.7	0.6	1070.1	6.2	0.3	1.0
3/17/88	0.460	3063.8	4782.8	1064.5	94.6	-78.8	-1.8	1076.3	5.8	1070.5	11.4	0.4	0.9
6/10/88	0.233	3070.5	4760.7	1063.5	99.2	-81.3	-2.8	1075.8	5.0	1070.8	10.6	0.3	1.3
9/17/88	0.271	3077.1	4736.9	1062.1	91.3	-82.8	-3.6	1071.5	0.8	1070.7	6.4	-0.1	-0.4
2/16/89	0.416	3088.1	4699.5	1060.4	93.8	-81.8	-2.8	1074.8	2.9	1071.9	8.5	1.2	2.9
6/17/89	0.331	3094.9	4669.3	1059.0	93.6	-85.9	-2.9	1074.7	1.7	1073.0	8.0	0.4	1.2
10/03/89	0.296	3100.0	4644.0	1057.0	87.5	-87.3	-4.9	1069.9	0.0	1069.9	3.2	0.0	0.0
				STAKE 89-B2									
10/08/89		3053.8	4902.7	1068.1				1069.9	0.6	1069.3	6.4		
2/14/90	0.353	3063.6	4875.2	1066.9	82.8	-78.2	-2.6	1072.2	2.5	1069.7	8.4	0.3	0.8
6/03/90	0.298	3072.9	4850.7	1065.9	88.0	-76.9	-2.4	1071.0	2.0	1069.0	7.8	-0.6	-2.0
9/06/90	0.260	3080.6	4831.2	1064.7	80.8	-76.1	-3.6	1066.0	0.0	1066.0	2.5	0.3	1.2
1/06/91	0.334	3088.9	4808.1	1063.4	73.6	-78.0	-3.4	1066.3	1.1	1065.2	3.5	-0.7	-2.1
5/13/91	0.348	3096.4	4780.7	1062.1 E	81.7	-83.0	-2.9	1069.5	3.3	1066.2	5.7 E	1.0	2.9
9/12/91	0.334	3107.2	4754.5	1060.8	84.9	-75.1	-2.9	1064.6	0.0	1064.6	1.3	-0.5	-1.5
				STAKE 91-B									
5/13/91		3046.5	4884.9	1064.3				1069.5	3.3	1066.2	9.8		
9/12/91	0.334	3057.3	4858.6	1063.0	85.2	-75.2	-2.9	1064.6	0.0	1064.6	5.0	-0.1	-0.3
1/22/92	0.361	3066.6	4833.9	1061.8	73.2	-77.1	-2.9	1067.8	3.2	1064.6	8.1	0.1	0.3
5/13/92	0.307	3075.6	4811.2	1060.0	79.8	-76.0	-4.7	1069.0	3.7	1065.3	8.7	0.6	2.0
9/03/92	0.309	3083.6	4786.7	1059.7	83.4	-79.9	-0.7	1064.1	0.0	1064.1	3.7	0.1	0.3
2/16/93	0.454	3094.0	4754.9	1057.9	73.8	-79.9	-3.4	1067.2	3.0	1064.2	6.8	0.0	0.0
5/15/93	0.241	3099.1	4737.1	1056.9	76.9	-82.2	-3.4	1068.6	4.1	1064.5	7.9	0.3	1.2
				STAKE 93-B									
5/15/93		3024.9	4898.8	1065.3				1068.6	4.2	1064.4	9.2		
9/10/93	0.323	3036.6	4872.7	1064.3	88.6	-73.2	-2.2	1063.5	0.0	1063.5	3.4	0.7	2.2
2/05/94	0.405	3048.5	4844.3	1063.1	76.1	-74.7	-2.5	1066.1	2.7	1063.4	5.9	0.1	0.2
5/13/94	0.266	3056.3	4825.0	1062.4	78.3	-75.5	-2.1	1067.5	3.7	1063.8	7.0	0.3	1.1
9/10/94	0.329	3065.7	4799.8	1061.2	81.8	-77.3	-2.8	1062.3	0.0	1062.3	2.0	-0.2	-0.6
1/31/95	0.392	3075.0	4773.4	1059.8	71.5	-78.4	-3.2	1065.9	3.3	1062.6	4.9	0.7	1.8
5/14/95	0.282	3081.6	4753.4	1058.8	74.8	-79.7	-3.0	1067.1	4.3	1062.8	6.0	0.1	0.4
				STAKE 94-B									
5/13/94		3054.0	4874.3	1060.4				1067.5	3.7	1063.8	11.2		
9/10/94	0.329	3064.5	4849.0	1059.3	83.3	-75.0	-2.6	1062.3	0.0	1062.3	6.1	-0.1	-0.3
1/31/95	0.392	3074.6	4822.6	1058.0	72.2	-76.7	-2.9	1065.9	3.3	1062.6	9.3	0.4	1.0
5/14/95	0.282	3081.8	4802.7	1057.1	75.1	-77.9	-2.7	1067.1	4.2	1062.9	10.2	0.3	1.1
9/15/95	0.339	3090.8	4777.8	1055.8	78.2	-77.9	-3.1	1062.2	0.0	1062.2	5.1	0.2	0.6
1/12/96	0.326	3097.5	4756.9	1054.5	67.4	-80.3	-3.8	1063.3	2.0	1061.3	6.6	-0.4	-1.2
				Average:	83.7	-79.3	-2.8	1068.6	2.2	1066.4	5.9	0.5	0.8

Table 14. Glacier motion and surface altitude data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska

[*X, Y,* and *Z*, coordinates of the stake base, E indicates estimate using measurement of a nearby stake, see Glacier motion section for method; *S*, average speed; θ, horizontal glacier surface motion direction, positive counterclockwise from grid East; ϕ, dip of glacier surface motion, positive up from hoizontal; Z_I, glacier surface altitude at fixed-location measurement site; *d* snow depth; Z_{ss}, summer surface altitude at the fixed-location site; *b′*, stake reading (either *b′, b**, or *b*** from tables 2, 3, and 4), height of glacier surface above the stake base; *e*, glacier motion emergence, the amount of ice motion rise (+) upward toward the surface; submergence (-) downward, the amount a glacier would change in thickness at a site with a mass balance of zero; S_e, emergence speed; motion terminology after Meier, 1960; ---, no data available. See Glacier motion and surface altitudes section for method of measurement. Abbreviations: m/d/y, month/day/year, yr, year; m, meter; grad, a measure of angle, a right angle is 100 grad]

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth *d*	Summer Surface Altitude Z_{ss}	Stake Reading *b′*	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
Site C--Initial location, X=2,160.5 m and Y=6473.6 m.													
		STAKE 75-C											
2/06/75		2095.2	6500.5	1278.1				1283.8	3.4	1280.4	6.4		
6/03/75	0.320	2095.4	6489.6	1277.7	34.1	-98.8	-2.3	1285.8	5.4	1280.4	8.5	-0.1	-0.3
8/21/75	0.216	2096.3	6481.4	1277.2	38.2	-93.0	-3.9	1281.9	2.0	1279.9	5.2	-0.6	-2.8
10/27/75	0.183	2096.5	6475.6	1276.8	31.7	-97.8	-4.4	1282.5	0.9	1281.6	6.0	-0.2	-1.1
2/23/76	0.326	2097.4	6464.6	1276.3	33.9	-94.8	-2.9	1284.3	3.0	1281.3	8.1	-0.3	-0.9
7/13/76	0.386	2097.9	6450.7	1275.8	36.1	-97.7	-2.3	1283.9	2.6	1281.3	7.7	0.0	0.0
10/20/76	0.271	2098.9	6441.1	1274.9	35.8	-93.4	-5.9	1283.1	2.3	1280.8	7.4	-0.5	-1.8
		STAKE 77-C											
2/25/77		2161.4	6472.8	1284.6				1289.2	8.9	1280.3	4.6		
6/08/77	0.282	2162.2	6462.5	1283.5	36.8	-95.1	-6.8	1288.7	9.0	1279.7	4.8	-0.7	-2.5
		STAKE 77-C2; 100 m east of initial measurement site.											
6/08/77		2263.2	6515.5	1278.5				1288.7	9.0	1279.7	10.3		
10/24/77	0.378	2262.2	6501.3	1278.4	37.7	-104.5	-0.4	1285.5	3.0	1282.5	8.9	-1.8	-4.8
2/28/78	0.348	2260.9	6487.7	1277.0	39.5	-106.1	-6.5	1288.4	6.5	1281.9	12.3	-0.5	-1.4
9/29/78	0.583	2260.1	6463.0	1275.0	42.5	-102.1	-5.1	1284.1	0.2	1283.9	9.6	-1.6	-2.7
Site C--Location moved on 2/28/78 to glacier centerline; X=2,353.1 m and Y=6,553.2 m, about 200 m east of the initial location.													
		STAKE 78-1.8C											
2/28/78		2363.2	6563.4	1285.5				1294.7	6.5	1288.2	9.8		
6/02/78	0.257	2363.0	6553.3	1284.5	39.4	-101.3	-6.3	1295.1	7.8	1287.3	11.0	-0.8	-3.1
9/29/78	0.326	2361.3	6541.2	1282.9	37.8	-108.9	-8.3	1290.3	0.2	1290.1	7.3	-1.1	-3.4
3/07/79	0.435	2359.1	6526.2	1280.9	35.1	-109.3	-8.4	1293.2	4.2	1289.0	11.3	-1.1	-2.5
		STAKE 79-1.8C											
3/07/79		2379.3	6588.3	1288.4				1293.2	4.2	1289.0	7.3		
8/04/79	0.411	2376.5	6573.1	1286.5	37.9	-111.6	-7.8	1290.3	2.4	1287.9	5.5	-1.1	-2.7
		STAKE 80-1.8C											
1/11/80		2356.6	6577.3	1286.3				1291.6	4.9	1286.7	6.5		
6/06/80		Stake buried											
		STAKE 80-C2											
6/06/80		2355.2	6570.3	1291.5				1295.7	----	----	5.0		
7/30/80	0.148	2354.1	6564.7	1290.6	39.0	-112.3	-10.0	1292.8	----	----	2.7	-0.6	-4.1
9/05/80	0.101	2353.6	6560.8	1289.9	39.5	-108.1	-11.2	1291.4	----	----	1.7	-0.4	-4.0
		STAKE 81-C											
1/26/81		2356.2	6569.1	1293.3				1297.6	12.1	1285.5	5.0		
6/04/81	0.353	2353.6	6555.0	1291.4	41.0	-111.6	-8.4	1298.1	13.6	1284.5	6.8	-1.3	-3.7
9/01/81	0.244	2352.4	6544.7	1289.8	43.0	-107.4	-9.7	1293.9	9.7	1284.2	3.7	-1.1	-4.5
1/23/82	0.394	2351.1	6530.2	1287.4	37.4	-105.7	-10.4	1295.9	3.9	1292.0	7.5	-1.8	-4.6
6/26/82	0.422	2347.8	6511.6	1285.5	45.0	-111.2	-6.4	1295.8	5.0	1290.8	8.6	-1.2	-2.8
9/01/82	0.183	2347.5	6504.9	1284.5	37.1	-102.8	-9.4	1292.8	2.7	1290.1	6.3	-0.7	-3.8
		STAKE 81-C2											
6/05/81		2350.0	6536.2	1283.3				1298.1	13.5	1284.6	13.9		
9/01/81	0.241	2348.6	6524.2	1282.3	50.3	-107.4	-5.3	1293.9	9.7	1284.2	10.2	-0.5	-2.1
1/23/82	0.394	2347.6	6509.5	1280.5	37.7	-104.3	-7.7	1295.9	3.9	1292.0	13.6	-1.4	-3.6
9/01/82	0.605	2344.2	6485.1	1277.9	40.9	-108.8	-6.7	1292.8	2.4	1290.4	12.1	-1.6	-2.6

Table 14. Glacier motion and surface altitude data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates X	Y	Z	Glacier Motion Vector Speed S	Direction θ	Slope ϕ	Surface Altitude Z_I	Snow Depth d	Summer Surface Altitude Z_{ss}	Stake Reading b'	Emergence Rise e	Speed S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
			STAKE 82-C										
1/23/82		2355.6	6581.2	1293.4				1295.9	3.9	1292.0	3.7		
6/26/82	0.422	2353.1	6564.9	1291.7	39.3	-109.7	-6.5	1295.8	4.8	1291.0	4.6	-1.0	-2.4
9/01/82	0.183	2352.0	6557.9	1290.6	39.2	-109.9	-9.8	1292.8	2.5	1290.3	2.3	-0.7	-3.8
1/14/83	0.370	2350.3	6544.8	1289.1	35.9	-108.2	-7.2	1295.7	3.5	1292.2	6.2	-1.0	-2.7
6/15/83	0.416	2347.4	6527.5	1286.9	42.5	-110.6	-7.9	1296.5	5.6	1290.9	8.3	-1.3	-3.1
			STAKE 83-C										
1/14/83		2363.4	6574.6					1295.7	3.1	1292.6	4.3		
6/15/83	0.416	2361.4	6558.3		39.9	-107.8	-9.6	1296.5	5.5	1291.0	6.6	-1.5	-3.6
9/02/83	0.216	2359.9	6550.1		38.9	-111.5	-8.4	1292.6	2.5	1290.1	3.6	-0.9	-4.2
			STAKE 83-C2										
6/15/83		2364.9	6627.2	1290.8				1296.5	5.5	1291.0	9.4		
9/02/83	0.216	2363.3	6619.7	1289.6	35.9	-113.4	-9.9	1292.6	2.4	1290.2	6.3	-0.8	-3.7
1/19/84	0.381	2360.8	6605.9	1287.6	37.2	-111.4	-9.0	1296.6	4.3	1292.3	10.9	-0.6	-1.6
6/08/84	0.386	2358.2	6592.4	1285.7	36.0	-112.1	-8.7	1296.3	5.8	1290.5	12.4	-1.8	-4.7
8/20/84	0.200	2357.3	6585.2	1284.6	36.7	-107.9	-9.6	1292.3	2.7	1289.6	9.2	-0.8	-4.0
1/13/85	0.400	2354.9	6571.7	1282.8	34.6	-111.2	-8.3	1294.5	3.6	1290.9	12.5	-1.1	-2.8
6/05/85	0.392	2352.8	6557.1	1281.5 E	37.8	-109.1	-5.6	1296.7	6.4	1290.3	15.2 E	-0.5	-1.3
8/27/85	0.227	2351.6	6548.9	1280.2	37.0	-109.3	-9.9	1293.1	3.6	1289.5	12.6	-1.0	-4.4
			STAKE 85-C										
6/05/85		2349.6	6587.3	1289.6				1296.7	6.4	1290.3	8.3		
8/27/85	0.227	2348.4	6579.1	1288.3	37.0	-109.3	-9.9	1293.1	3.7	1289.4	5.6	-0.9	-4.0
2/19/86	0.482	2345.8	6562.1	1286.0	36.0	-109.7	-8.5	1297.5	5.7	1291.8	11.5	-1.5	-3.1
6/15/86	0.318	2344.3	6550.3	1284.5	37.7	-108.0	-8.0	1296.6	5.8	1290.8	11.6	-1.0	-3.1
8/20/86	0.181	2344.1	6543.6	1283.6	37.4	-101.9	-8.5	1293.3	2.9	1290.4	8.7	-0.4	-2.2
			STAKE 86-C										
2/18/86		2350.1	6571.4	1294.9				1297.5	5.8	1291.7	3.3		
6/15/86	0.320	2348.4	6559.6	1293.3	37.6	-109.1	-8.5	1296.6	5.8	1290.8	3.4	-1.0	-3.1
			STAKE 86-C1										
6/15/86		2354.1	6572.8	1288.8				1296.6	5.8	1290.8	8.7		
8/20/86	0.181	2353.0	6565.7	1287.7	40.2	-109.8	-9.7	1293.3	2.8	1290.5	5.7	-0.3	-1.7
			STAKE 87-C										
6/13/87		2338.0	6542.0	1289.4				1298.3	8.3	1290.0	7.8		
10/01/87	0.301	2336.3	6530.4	1287.6	39.4	-109.3	-9.7	1295.5	1.5	1294.0	6.4	-1.4	-4.7
3/19/88	0.465	2334.4	6511.4	1285.8	41.2	-106.3	-6.0	1300.8	7.8	1293.0	12.9	-1.2	-2.6
			STAKE 88-C										
3/19/88		2340.8	6508.6	1288.6				1300.8	7.8	1293.0	10.1		
6/10/88	0.227	2340.0	6498.6	1287.6	44.4	-105.1	-6.3	1300.0	7.6	1292.4	9.9	-0.6	-2.6
9/18/88	0.274	2339.3	6486.2	1286.0	45.7	-103.6	-8.2	1295.7	0.2	1295.5	6.7	-1.1	-4.0
2/16/89	0.413	2338.4	6469.4	1283.6	41.1	-103.4	-9.0	1297.9	4.2	1293.7	10.7	-1.8	-4.4
6/17/89	0.331	2337.3	6454.7	1282.1 E	44.8	-104.8	-6.5	1297.8	4.7	1293.1	11.2	-0.6	-1.8
10/08/89	0.309	2337.0	6441.7	1280.5	42.4	-101.5	-7.8	1292.8	0.7	1292.1	7.4	-1.2	-3.9
			STAKE 89-C										
10/08/89		2364.4	6576.2	1288.4				1292.8	0.7	1292.1	5.8		
2/14/90	0.353	2362.6	6563.9	1287.3	35.4	-109.3	-5.6	1295.0	3.5	1291.5	8.6	-0.6	-1.7
6/02/90	0.296	2361.0	6553.4	1286.0	36.2	-109.6	-7.8	1294.5	3.5	1291.0	8.7	-0.6	-2.0
9/06/90	0.263	2358.9	6544.8	1284.8	34.0	-115.2	-8.6	1289.2	0.0	1289.2	4.3	-0.9	-3.4
1/06/91	0.334	2358.1	6534.2	1283.7	32.0	-104.8	-6.6	1290.3	2.0	1288.3	6.1	-0.7	-2.1
5/16/91	0.356	2358.0	6521.5	1283.1 E	35.7	-100.5	-3.0	1294.1	6.3	1287.8	10.4 E	-0.5	-1.4
9/18/91	0.342	2355.1	6509.5	1281.5	36.4	-115.1	-8.2	1289.2	1.9	1287.3	5.9	-0.4	-1.2

Table 14. Glacier motion and surface altitude data from site C (1,290 meters altitude) on Wolverine Glacier, Alaska--Continued

Date	Period Since Last Survey	Stake Location Project Grid Coordinates			Glacier Motion Vector Speed	Direction	Slope	Surface Altitude	Snow Depth	Summer Surface Altitude	Stake Reading	Emergence Rise	Emergence Speed
		X	Y	Z	S	θ	ϕ	Z_I	d	Z_{ss}	b'	e	S_e
m/d/y	yr	m	m	m	m/yr	grad	grad	m	m	m	m	m	m/yr
			STAKE 91-C										
5/16/91		2352.5	6590.9	1287.7				1294.1	6.0	1288.1	8.0		
9/18/91	0.342	2349.6	6579.0	1286.2	36.1	-115.2	-7.8	1289.2	1.8	1287.4	3.7	-0.6	-1.8
9/18/91		2352.8	6673.8	1289.5				1289.2	1.8	1287.4	4.8		
1/25/92	0.353	2350.6	6664.5	1288.3	27.3	-114.8	-8.0	1293.4	5.0	1288.4	8.0	1.0	2.8
			STAKE 92-C										
1/25/92		2350.9	6661.0	1292.1				1293.4	5.0	1288.4	5.8		
5/13/92	0.298	2349.3	6651.5	1290.9	32.6	-110.6	-7.9	1293.7	6.4	1287.3	7.2	-1.1	-3.7
9/03/92	0.309	2347.1	6641.4	1289.0	34.0	-113.7	-11.6	1289.1	0.0	1289.1	3.2	-0.6	-1.9
2/08/93	0.433	2344.8	6628.6	1287.3	30.3	-111.3	-8.3	1291.4	3.6	1287.8	6.7	-1.2	-2.8
5/15/93	0.263	2343.6	6620.2	1286.6	32.4	-109.0	-5.2	1294.3	6.8	1287.5	10.0	-0.4	-1.5
9/13/93	0.331	2341.7	6609.4	1285.1	33.4	-111.1	-8.7	1287.8	1.4	1286.4	4.5	-1.0	-3.0
2/05/94	0.397	2340.6	6597.3	1285.2 E	30.6	-105.8	0.5	1291.1	3.9	1287.2	6.3 E	1.5	3.8
5/13/94	0.266	2339.1	6588.8	1284.4	32.6	-111.1	-5.9	1292.7	6.0	1286.7	10.5	-2.6	-9.8
			STAKE 94-C2										
2/05/94		2347.4	6590.5	1285.9				1291.1	4.0	1287.1	6.3		
5/13/94	0.266	2345.8	6582.1	1285.2	32.3	-112.0	-5.2	1292.7	6.0	1286.7	8.3	-0.4	-1.5
9/07/94	0.320	2344.3	6571.2	1283.8	34.7	-108.7	-8.1	1287.6	1.8	1285.8	4.2	-1.0	-3.1
2/01/95	0.402	2342.5	6558.8	1282.4	31.4	-109.2	-7.1	1291.4	4.6	1286.8	8.8	-0.8	-2.0
5/14/95	0.279	2340.5	6549.9	1281.5	32.9	-114.1	-6.3	1292.9	6.4	1286.5	10.7	-0.4	-1.4
9/14/95	0.337	2339.9	6537.4	1280.3	37.3	-103.1	-6.1	1288.2	2.5	1285.7	6.8	-0.8	-2.4
1/13/96	0.331	2338.8	6526.4	1279.0	33.6	-106.3	-7.5	1289.8	3.0	1286.8	9.2	-0.8	-2.4
				Average:	37.2	-107.3	-7.3	1292.8	4.6	1288.2	7.7	-0.8	-2.7